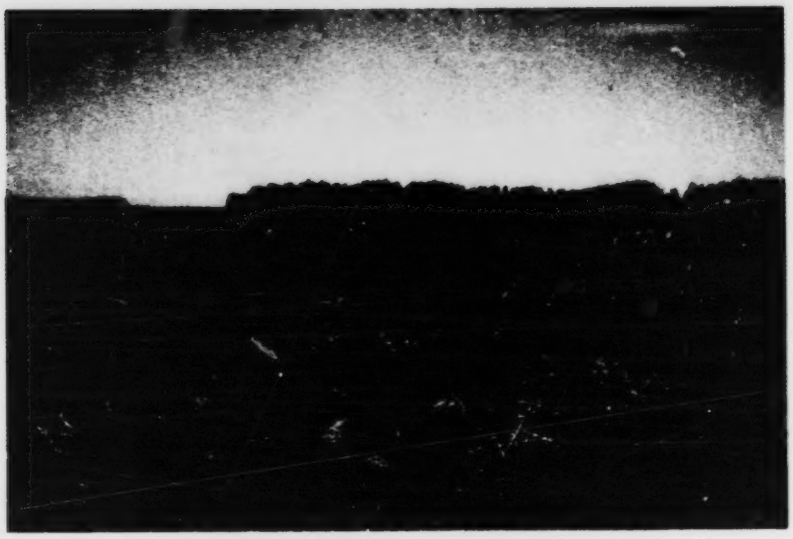
AGRICULTURAL IMPACT STUDY

Concerns of Future Strip Mining in the Battle River Regional Planning Commission

by

L. D. WILLIAMS, P. AG.



Prepared for Battle River Regional Planning Commission

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L. D. WILLIAMS
AGRICULTURAL SERVICES

4615 - 49 Street
Camrose, Alberta
T4V 1M4

Larry Williams, P. Ag.
Phone: 672-3266

Mr. Owen Hamblin, Chairman
Battle River Regional Planning Commission
5014 - 48th Avenue
WETASKIWIN, Alberta
T9A OM9

It is a pleasure for me to submit this Agricultural Impact Study to you at this time.

I would like to acknowledge the work Don Young, Senior District Agriculturist at Wetaskiwin shared with me in preparing and writing the chapter on North Dakota, Montana and Wyoming and his advice in compiling the balance of the report.

Research institutions, some government agencies, different members of industry and many interested members of the public were very supportive during the preparation of the report.

Special appreciation is extended to members and employees of the Battle River Regional Planning Commission for their advice and assistance and patience during its preparation and publication.

Yours truly,

L. D. Williams

L. D. Williams, P. Ag.

LDW/mtl

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Battle River

Regional Planning Commission

5014 - 48 Avenue Wetaskiwin, Alberta T9A 0M9
Telephone (403) 352-2215
Edmonton Line (403) 424-6310

Your Ref

Our Ref

October 24th., 1978.

Mr. L. D. Williams,
4615 - 49th. Street,
CAMROSE, Alberta.

Dear Sir:

Re: Coal Areas Study

Further to our conversations on the above study, I would suggest the "Problem" we are trying to solve is: Under what conditions could the Commission support the development of coal deposits from an Agro-Economic point of view?

As was discussed the terms of reference with regard to research materia' available - existing land use and outputs - methods of reclamation etc., all would appear to be within the probable scope of the study.

I would suggest this item should be brought before the Commission and discussed for their input and guidance.

I would suggest if you could attend the Commission Meeting on October 25th., 1978 at approximately 10:00 A.M. we could bring it up under Unfinished Business.

Yours truly,

R. H. Botham,
Director.

RHB/bmd

BATTLE RIVER PLANNING COMMISSION

AGRICULTURAL IMPACT STUDY

Situation

The geographic area represented on the Battle River Planning Commission includes large tracts of agricultural productive soil that serves as overburden for potential mineable coal deposits at various depths. Many of these coal deposits lend themselves to economic development using strip mining techniques.

Purpose of Study

To provide criteria for the assessment of surface coal mining development applications from an agricultural viewpoint within the area served by the Battle River Planning Commission.

Objectives of the Study

1. To establish the degree and extent of conflict between two land uses - agriculture and surface coal mining.

2. To determine the agricultural capability of local areas.

3. To review, summarize and record land reclamation studies which could be applicable in the Battle River Planning Commission area.

4. To provide information regarding alternate uses of reclaimed land within industry, e.g. grain growing versus livestock grazing.

The Study Method

The study would be developed in stages.

1. Collection of information, e.g.
   (a) Soil survey maps for the area.
   (b) Coal bearing maps for the area.
   (c) Review sources of land reclamation studies and availability of information pertaining to the studies.

2. Develop an overview map showing the location of coal deposits in the Battle River Planning Commission area.

3. Include an agricultural capability study. This report would be prepared using information available from:
   (a) Farmers in the area.
   (b) Marketing reports
   (c) Soil capability studies.
   (d) Yield data reports.
   (e) Other sources.

4. List coal mining activities where reclamation of agricultural land is being undertaken in other parts of the world.

5. Summarize studies of land reclamation being done in geographic areas with similar agricultural potential.

6. Personally visit, inspect and evaluate reclamation work that is being done. The inspection visits would be done during the growing season to observe crop growth in reclaimed soils.

7. Prepare an outline of criteria or conditions for consideration when applications for strip mining are being reviewed.

8. Prepare report and submit using present policies and guidelines in the Battle River Regional Plan. The detailed report to be prepared in cooperation with Mr. Botham and staff of the Battle River Regional Planning Commission.

L. D. Williams, P. Ag.

FORWARD

The Battle River Planning Commission began this study in late 1978 because of its concern for the orderly and economic development of the coal resources in the region. Inquiries directed to the Commission indicated that the demand for coal as an alternate energy source would initiate demands for development in the foreseeable future.

Many questions raised during the discussions following the presentation of the Dodds-Round Hill strip mining proposal were not answered. What effect would such a development have on the agricultural productive capability of land in the region? What would the preconditions be when considering an application in the Battle River Commission region? Could the lines of communication be opened up between the Commission, industry, farm community, and the government?

Incomplete information pertaining to these and other questions and concerns expressed by members of the farm community prompted the initiation of this study. The review of literature and visits with different agencies could indicate other studies worthy of investigation. Such studies could compliment data available to an agency charged with the responsibility of deciding whether a strip mining operation should or should not proceed from a land use point of view. The Energy Resources Conservation Board addresses itself to the economic aspect of a proposal but does not really give consideration to the dislocation or long range re-use of property.

Hopefully this study has considered those issues and has made sincere and practical recommendations or observations.

INTRODUCTION

The Battle River Regional Planning Commission is one of eight regional planning commissions established in the Province of Alberta. All eight commissions[1] are established by regulation by the Lieutenant Governor in Council. The commissions operate under the authority vested in them by the Planning Act, 1977, and are responsible to the Minister of Municipal Affairs. A Commission is comprised of representatives of councils designated by the Minister to be included on the Commission. Once established, the commission may appoint non voting individuals to act on committees in an advisory capacity.

As the title indicates, Regional Planning is one of the responsibilities assumed by the commission when it is organized under provisions of the Planning Act. Additional responsibilities include giving assistance with the development of (1) general plans for local councils represented on the commission, (2) a land use by-law, or both of them.

The commission is empowered to employ a person as a director of the commission and to employ or engage the services of other individuals as considered necessary to fulfill the obligations assumed by the commission.

The office of the Battle River Regional Planning Commission is located in Wetaskiwin. The Commission area covers a total land area of 3,378,760[2] acres in four rural counties in Alberta.

	Total Land Area	Assessed Area
County of Camrose No. 22	892,253 acres	870,267 acres
County of Flagstaff No. 29	999,436 acres	991,663 acres
County of Ponoka No. 3	705,405 acres	662,417 acres
County of Wetaskiwin No. 10	781,666 acres	675,175 acres
Total	3,378,760 acres	3,199,522 acres

The population of the Battle River Planning Commission region is 62,573[3] and is distributed almost equally between incorporated areas and rural areas plus hamlets. There are 34,860 people living in 2 cities, 7 towns, 14 villages and in 8 incorporated summer villages. The four counties and hamlets have a population of 27,713.

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(1) The Alberta Planning Act 1977, Queen's Printer, Edmonton, Alta.

(2) 1979 County Financial Statements

(3) Alberta Population Statistics - 1979. June 30, 1979. Advisory Services Branch, Alberta Municipal Affairs, Edmonton.

1979 POPULATION DISTRIBUTION

BATTLE RIVER PLANNING COMMISSION REGION

County of Camrose #22 Summary			
City of Camrose	11,210		
Town of Bashaw	870		
Seven Villages	1,478		
Hamlets & Rural County Population	7,362		
Total		20,920	
County of Flagstaff #29 Summary			
Four Towns	3,103		
Six Villages	2,028		
Hamlets & Rural County Population	4,653		
Total		9,784	
County of Ponoka #3 Summary			
Two Towns	6,532		
Rural County Population	7,223		
Total		13,755	
County of Wetaskiwin #10 Summary			
City of Wetaskiwin	8,592		
Village of Millet	815		
Eight Incorporated Summer Villages	232		
Rural County Population	8,475		
Total		18,114	
Total			62,573

Population Breakdown

2 Cities	19,802	
7 Towns	10,505	
14 Villages	4,321	
4 Counties	27,713	
8 Summer Villages	232	
Total		62,573

POPULATION DISTRIBUTION BY COUNTIES

CAMROSE

City of Camrose		11,210
Town of Bashaw		870
Bawlf	298	
Bittern Lake	140	
Edberg	140	
Ferintosh	166	
Hay Lakes	287	
New Norway	261	
Rosalind	186	
7 Villages - Total		1,478
County of Camrose #22		7,362
Sub Totals		20,920

FLAGSTAFF

Daysland	645	
Hardisty	671	
Killam	940	
Sedgewick	847	
4 Towns - Total -		3,103
Alliance	228	
Forestburg	901	
Galahad	184	
Heisler	215	
Lougheed	227	
Strome	373	
6 Villages - Total -		2,028
County of Flagstaff #29		4,653
		9,784

PONOKA

Ponoka	4,845	
Rimbey	1,687	
2 Towns - Total -		6,532
County of Ponoka #3		7,223
		13,755

WETASKIWIN

City of Wetaskiwin		8,592
Village of Millet		815
Crystal Springs	38	
Golden Days	21	
Grand View	30	
Itaska Beach	2	
Ma-Me-O Beach	87	
Poplar Bay	11	
Silver Beach	29	
Sundance Beach	14	
8 Summer Villages-Total-		232
County of Wetaskiwin #10		8,475
		18,114

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AREAS OF CONCERN REGARDING SURFACE COAL MINE APPLICATIONS

A. Land:
- Final Ownership
- Final Use
- Rural Utilities - Power, Gas, Telephone
- Ground Water Recharge
- Surface Water
- Hydrology

B. People:
- Knowledge about mining operations
- Participation in studies and decisions
- Movement, buying or renting or leasing of land
- Payments to land owners and/or tenant

C. Research:
- Lack of Provincial Government Research
- Lack of Research by the Universities
- Small amount being done by Private Coal Companies
- Lack of availability of research results
- Lack of communication between researchers
- Ground water supply

D. Soil:
- Pre-mining, mapping and inventory
- Stripping Methods/Re-application of Topsoil (Root Zone Material)
- Compaction/Ripping
- Water Storage for Crop Growth
- Erosion, Subsidence, Slumping, Piping
- Sodium
- Salinity
- Irrigation to help in reclamation
- Required Soil (Root Zone) Depth
- Replacement of Plant Nutrients
- Vegetation Establishment Forages vs. Cereals
- Chemical Reclamation
- Plant Species Adaptability
- Initial Reclamation vs. Sustained or Long Term Reclamation
- Ash and Salt Disposal

E. Reclamation:
- Definition
- Goals Set vs. Detailed Standards and Regulations
- Bonding Requirements
- Legislated requirements for particular species and diversity
- Costs of Reclamation
- Law provision for change in light of research

AREAS OF CONCERN REGARDING SURFACE COAL MINE APPLICATIONS

INTRODUCTION

A review of the literature indicates that surface mining of coal in Great Britain and West Germany really developed during the early post Second World War years. The demand for energy increased dramatically. Industries were converted from production of emergency war time supplies to civilian oriented industries. The interest in the surface mining of coal was stimulated by a number of factors. These factors amongst others included shortage of manpower to work in underground mines, improved mechanized equipment available for use, and economy of production.

Members of the coal mining industry in Great Britain accepted the challenge society presented to them. Operating units were put together. Mining expertise was modified and utilized to meet the demands of society for increased supplies of cheaper energy. The cheaper thermal generated power was needed to produce the goods and services members of a freedom loving society craved for many years. Members of the surface coal mining industry were able to fulfill these needs as long as their costs of production could be kept competitive with alternate sources of energy such as that provided by fossil fuels. The benefits the surface coal mining industry contributed to society can be well documented.

Associated with the benefits contributed to society, there were problems created that could not be ignored in Europe and should not be ignored in the Battle River Planning Commission area. The study showed that amny of the problems were resolved to the satisfaction of the people involved. The experiences gained in Europe where surface mined land restoration in twenty years older than here have much to offer when any surface coal mining project plan is being prepared. There are several areas of concern that appeared to evolve as the study progressed. The different areas are certainly interrelated.

Areas of Concern

A. Land

The abondoned or derelict surface mining site five miles south-east of Camrose is a familiar sight to many people. It is a real blotch on the horizon. Other individuals have mentioned the surface mining work at Estevan, Saskatchewan. These sites and others observed by people prompt such questions as "What use will be made of the land after mining?" "What will it grow?" "Who will own it?" "How can similar situations be avoided?" Recent Alberta legislation passed in 1977 would not allow similar situations to develop.

The surface mining application process used in Great Britain and West Germany, if used in the study area, would pre-answer many questions and build good public relations between industry, government and the public. The process in Europe involves a complete evaluation of the proposed mining project area. It considers the people, the post-mining land use, the community, the environment and other interrrelated concerns, such as the infrastructure involving roads, utilities, water supplies and services. A land restoration plan is one of the prime prerequisites that has to be developed and approved by the government agency responsible for final post-mining bond release.

The European literature indicates that many interested agencies are involved in the study. Before a final mining plan is submitted for consideration and approval, it is presented to many agencies for review, study and possible changes. In England, the plan must meet with the approval of the local administrative authorities as well as the Planning Authority before it is submitted to the Opencast Executive for further study. This Opencast Executive, a sub-committe of the National Coal Board, must be satisfied that an adequate land restoration program is included with the application. This Opencast Executive is the final restoration approval authority. The pre-mining plan is also reviewed in consultation with representatives of over twenty organizations. Recommendations on future land use are made and become a part of the application that is eventually reviewed by the National Coal Board.

In North Rhine Westphalia, West Germany, a similar procedure is followed. The Land Planning Commission, established in 1962, is charged with the responsibility of developing overall guidelines for land use within the State. The 1962 Planning Law also created the Brown Coal Committee to develop the detailed plans for mining the coal within the frame work and intent of the overall regional plan. This committee of 27 includes a cross section of interests most affected by the impact of the mining operations. Their recommendations are then submitted to the State office for consideration and approval by the Governor of the State.

In Great Britain the coal industry is nationalized. The coal rights are retained by the Crown. In West Germany the free enterprise system of mining is encouraged. The coal rights are retained by the State. However, both countries follow a very similar procedure when processing applications for surface mine developments. These two committees, the Opencast Executive in Great Britain, and the Brown Coal Committee in West Germany, operating in two separate countries with two different systems of government have the same responsibilities, namely, to produce coal economically, to consider the people on the land, and to protect a very valuable resource, the soil, for the use of future generations.

B. People

Many problems associated with surface mining projects could be minimized if better communication links were established. Knowledgeable informed people in the field of agricultrue should be employed to converse with the farmers that are going to be affected by a mining project. Efforts should be made to share as much information as possible. Farmers are progressive. They are interested in their farm, its operation, and their community. They want to know what alternatives they have when potential surface mining projects are being considered for their area.

Farmers approaching retirement age have different needs than younger established farmers. These potential retired farmers are aware of their needs. For most of them the farm unit is their retirement income.

Family Farms set up as partnerships or incorporated units have different requirements to be considered. For many of them, the reduction in size of farming units could cause economic hardship not of their own choosing. Farmers obliged to relocate have unexpected and unplanned costs to consider. Some farmers consider that land purchased or leased for industrial use, either permanently or short term, has a different value than agricultural values offered by some potential surface mine developers. The philosophy expressed by some surface mining proponents that top soil is "waste", or "spoil", or "dirt", and has little value, is changing. It needs to change. Legislation requires it. Members of society demand it.

Farmers who expect to resume the active operation and management of their farming unit after mining are concerned about productive capabilities of restored surface mined land. The concerns of these farmers and others could be lessened if land restoration programs were monitored continuously by informed responsible people. This monitoring program should start as the pre-mining plan develops, and the top soil material along with the sub-soil root zone material are inventoried. The monitoring program should continue as the selection, sorting and stockpiling program progresses. This program would not be finished until the restoration program had satisfied the requirements of the governmental bonding regulations and the farmers who plan to resume their vocation as farmers and successful land owners in the community. Since land restoration or reclamation is a relatively new requirement and process in this part of Alberta, very little well documented post-mining agricultural data is available. Once this data is available for public scrutiny, the concerns of many farmers and others will be appeased.

Similar concerns of land owners, tenants and many agencies involved in administration, public health, services, utilities, urban development, wild life preservation, recreation etc., were recognized in Great Britain by the National Coal Board, and in West Germany by the Brown Coal Committee. In both countries, comprehensive pre-planning of surface coal mine operations was and is required within the regulatory framework of the two countries.

Guidelines are established for use when communicating with farm owners or operators and the general public. Premining plans are finalized, publicized and discussed well in advance of the start of any active mine development. In Great Britain many items are considered when lease agreements are completed. Lease compensation is paid in several stages. Initial compensation is paid prior to entry of the land for mine preparation. This initial compensation includes payment for agricultural disturbance and reasonable expenses incurred by the owner and/or the tenant when required to relocate while the property is being mined and restored. Periodic rental payments are made quarterly while the lease is active. These payments are reviewed every three years and are subject to upward adjustment. The rental payments are never reduced until the land has been restored to some level of utilization. A rehabilitation allowance equivalent to the previous year's annual rent is paid once the lease is terminated. Other financial arrangements are made if the land is to be used for some other purpose and cannot be utilized similar to pre-mining capabilities.

Restoration programs have been in place for some twenty years in Great Britain and the province of North Rhine Westphalia, West Germany. The programs developed have done a great deal to minimize social upheavals and environmental damage in surface-mined areas. The land restoration program in North Rhine Westphalia embodies four main principles which make it viable and effective.

1. The regulation of surface mining is incorporated within an overall regional development plan. Hence it is possible to consider the varied interests in the region.
2. A planning body composed of representatives from diverse interest groups participates in formulating detailed requirements for mining and land restoration long before the actual mining begins. A broad spectrum of society is consulted and untimely haste is avoided.
3. Final recommendations of the planning body are submitted for public review before being adopted and implemented. This provides a political pressure relief valve as well as a mechanism for detecting possible adverse side effects which had not been considered previously.
4. An enforcement agency is established to enforce the plan which is finally approved and adopted.

There may be some variation in the restoration programs in the two countries. The results they have achieved have been recognized by the responsible regulatory agencies and primary producers alike. It is not too late nor too soon to learn by their experiences. Their programs could be modified to suit our local problems and conditions. They have much to offer.

C. Research

Throughout the world, basic research, field research and applied research have been synonymous with the development of viable agricultural industries in many different countries. The value of research and its contribution to agriculture has been well documented. The need for more research became apparent when large areas of agricultural land were, of necessity, disturbed when surface coal mining enterprises were initiated and expanded in Great Britain and West Germany in the early post Second World War years.

In Europe questions directed to industry, government and research could not always be answered to the satisfaction of farmers, conservationists, and regulatory personnel amongst others. Research people from the Rothamstead Institute in England and the University of Bonn in West Germany were asked to assist with pre-mining plans and advise on different phases of the mining project and restoration prcedures as the individual mining program plans developed in their countries. The information tabulated from the shared cooperation of University Research scientists, members of industry and government agencies in research projects was very valuable. Use of the information made it possible for mine developers to meet the requirements enunciated in legislation. Primary producers and others were able to get answers to some of their questions. Land restoration was often by trial and error in the early years of surface coal mining development. Mining techniques changed. Agricultural research information became more meaningful. Opposition to surface coal mining projects became less vehement. Pre-mining impact studies were able to develop mining and land restoration programs acceptable to the approval authorities and to many of the local people affected by the disturbance.

Land restoration after surface coal mining in the U.S.A. was not required on a national basis until 1977. Different States had legislation enacted and regulations approved in prior years. Some of the restoration requirements were minimal to nil. The main thrust was to develop coal mining projects. Land restoration was limited to planting trees in the 1920's. Some disturbed lands were eventually reclaimed as pasture land. Concerns for the environment and demands by the public prompted different States such as Montana, Illinois, and North Dakota to update and strengthen their land reclamation legislation. The mining companies were obliged to initiate land reclamation programs. Different states provided funds to universities to do research on disturbed mined lands within the state. Research information compiled and published was made avilable to mining companies, for their reference and use, where applicable. The state authorities also used the information when updating and strengthening their reclamation laws and regulations.

Since the first research studies done in the late 1960's in Montana and North Dakota, the research organizations such as the University of North Dakota at Fargo, the Northern Great Plains Research Centre at Mandan, North Dakota, and Montana State University at Bozeman, Montana, have done some very meaningful studies on the reclamation of cereal crop land on a plot basis. Cereal plot studies have been and are being done in the area west and north of Bismarck, North Dakota, on a rather limited plot scale. The active mining companies in the area cooperate with the research people involved in the studies. Much of the research work visited in North Dakota was done on soils somewhat similar to soils found in localized areas within the Battle River Planning Commission area.

As indicated earlier in the paper, surface mining has been a fact of life in Western Canada for many years. However, there has been a real lack of concern regarding the reclamation of this surface mined land. The lack of research by soil research scientists of our plains universities in establishing methods for restoration and reclamation of surface mined lands is very evident. No concerted program has been started by them to date. The Canada Research Stations in Lethbridge and

Lacombe could develop techniques for post-mining reclamation and suggest species suitable for post-mining revegetation. The Research Council of Alberta has set up projects to develop some standards for post-mine reclamation. A review of the literature shows that most of this work was done in the Foothills or on the eastern slopes of the Rockies. Very little work has been done, or is being done, in the plains region of Alberta where an estimated 82% of recoverable coal reserves of Alberta are located.

Alberta Power Ltd., Manalta Coal Ltd., and Forestburg Collieries Ltd. are developing an extensive reclamation research project at an operating coal mine south of the Battle River Generating Station near Forestburg, Alberta. This project is being developed in cooperation with the Land Surface Conservation and Reclamation Council of Alberta. The research project has been planned and developed to provide information to satisfy the requirements contained in the Alberta Land Conservation and Reclamation Act 1974. It is referred to as the Battle River Regional Reclamation Project (B.R.R.R.P.).

Present grovernment policies require that industry provide its own mining research data. This is unfortunate. There are only a few mining companies involved in surface mining in the Plains Coal Region of Alberta. They are operating in a very competitive atmosphere and reluctant to share knowledge gained by mining and reclamation activities. Reclamation knowledge should be shared. It should be available so that all the people of the province would eventually benefit.

The people of Alberta and others will benefit from the hydrogeological study initiated by the Research Council of Alberta in the general Forestburg area. This study has been set up to study ground water supplies, underground geological formations, and the effect of surface mine developments on ground water supplies in the restored surface area, along with undisturbed non-mined land in the adjacent areas. The study should compliment the information obtained from the B.R.R.R.P. It should also compliment the hydrology studies done by the Earth Science Division of Alberta Environment to determine the effect of a proposed mining project on ground water supplies within a localized mining project area.

The development of all of the different studies associated with surface mining is good. Communication between the various research arms of government, universities and members of private industry appears to be lacking. They all have much to offer. Communication and exchange of research information could be facilitated if members of the research community, the surface coal mining companies, and all government departments having a direct interest in proper land restoration and reclamation, could meet together to share successes and discuss failures. Improved communication is necessary if land restoration or reclamation is assured in the Plains Coal Region of Alberta, which covers some 250,000 square kilometres and contains approximately 82 per cent of the total area underlain by coal-bearing strata in Alberta.

D. Soils

"The soil is the most important natural resource of Canada and probably the most complex. It is treated with less understanding than any other resource. Its value is dependent on the way it is handled and the use made of it". (anonymous)

Since there has been little reclamation required after surface mining in either Saskatchewan or Alberta the appropriate mining technology for the selective stripping and stockpiling of topsoil, toxic and non-toxic spoils has not been developed. Further work in mining engineering and materials handling is needed to determine the best and most economic method of stripping. Is a two or a three lift method required? Coupled with the stripping and stockpiling process, what are the best methods of re-applying the clean sub-soil root zone material and the topsoil? How effective and economic is the use of earthmovers and dozer tractors in replacing or transferring the root zone material?

If heavy eathmoving equipment is used, will sub-soil compaction be a problem? Observations made in Illinois and Kansas indicate that ribbing of compacted soil is done at regular intervals as the reclamation process progresses. Evidence gathered in the Northern States indicates that deep sub soil ripping may be necessary to ensure adequate moisture and root penetration.

Some states have a provision requiring the stockpiling of soil from each land owner's parcel separately and replacing it separately. Is this a necessary requirement?

What changes are there in the soil's ability to hold water for crop growth? Research in North Dakota and Montana indicates there are problems in this area. Research is needed on Alberta soils under Alberta conditions.

How will Alberta soils be affected by the joint problems of erosion, subsidence, slumping and piping? These problems have proven serious in the Northern States, as well as to some degree in Alberta and Saskatchewan. Subsidence and erosion have been observed in Illinois and Kansas, and have been reported in literature reviewed from Great Britain and West Germany. Piping and slumping have been observed as problems in high sodium spoils. The overburden on large areas of coal in the Battle River Planning Commission area could contain excess sodium in the profile. Piping has been observed at the Forestburg Manalta mine site, but not to the degree seen in some areas in the United States. How serious could these problems become? What means can be taken to prevent them from becoming a serious problem?

A large acreage of land in the County of Flagstaff No. 29, and the County of Camrose No. 22 is classed as solonetz. These soils are sometimes underlain by a highly saline parent material. When mined, the major problems of excess sodium and salinity are created. The problems have been briefly described in the chapter on the Northern States and very extensively discussed in the reference material cited. What reclamation methods will work under Alberta conditions? North Dakota literature suggests that a minimum of three feet of non sodic, non saline root material is needed as cover for unaffected crop growth. Is this guideline applicable in Alberta? If not, what guidelines should be adopted?

In areas where three feet of uncontaminated top soil is not available the use of chemical amendments have been tried. These include the use of lime, gypsum, sulfur and clacium chloride. Can any of these materials be used successfully and economically here in Alberta?

Work done at Mandan suggests that irrigation helps in the establishment of forage crops, and may help by leaching some of the potentially harmful salts down into the soil profile. Will the same hold true in Alberta?

What fertilizer programs will be necessary to ensure adequate reclamation? Since this will vary from site to site it is suggested that this may be a site specific problem and should be investigated as such.

It has been the author's observation that the majority of crops grown on reclaimed land are forages. It seems to be the popularly held idea if land is reclaimed to the point at which it can grow grasses and legumes, then it must be able to grow cereal crops. A search of available literature fails to turn up a great deal of evidence to support this idea. The amount of cereal plot work observed and reported is minimal. A serious and extensive research program is needed to determine the capability of reclaimed land to support cereal crop production. This extensive research program should be initiated as soon as practical.

What is the adaptability of various species to the reclaimed land? A great deal of work has been done in the United States on appropriate grass species for different areas and even on different slopes having different exposures. This type of work is needed for Alberta conditions for grasses and legumes, as well as adaptability of various species of cereals.

A caution should be made here. Initial successful yields, after reclamation, may not be sustained with long term reclamation. In the United States, a five to ten year bond period is required after successful revegetation is established. In Great Britain and West Germany, ten year bond periods are required. The reclamation work is inspected and reviewed periodiacally. Adjustments may be made. In looking at the ability of land to produce food and fibre up to its former level, even ten years may be short sighted. Land in Alberta has taken some 10,000 years to develop to its present state. Once it has been disturbed by surface mining a ten year period may not be enough to

say whether reclamation has been successful or not. Perhaps a fifty year period would be more realistic. The point of this discussion is to point out the need to immediately initiate a major field test program to enable questions such as these to be answered.

Two other questions relating to soil should be discussed. One is the end point of the sulphur found in the coal. The E.R.C.B. indicates that the average sulphur content of coal in the Plains Coal Region of Alberta is usually less than 0.5%. This 0.5% sulphur content compares very well to the surface mined coals of Kansas and Missouri with a sulphur content of 5 to 7%. A modern plant such as the enlarged Battle River Generating Station south of Forestburg with a capacity of 8200 tons of coal per day would expel about .8 tons of sulphur into the atmosphere per day. Similarily the enlarged Sundance Generating Station south of Wabamun would expel about 2.2 tons of sulphur into the atmosphere. With prairie soils increasing in acidity what effect will this sulphur have if it settles in the form of acid rain?

The other questions of interest is the disposal of the ash from the coal. In some mines it is buried at the bottom of the cut. These ashes may carry high concentrations of heavy metals and salts. Will these salts and metals move from their burial place into ground water acquifers and then into streams and farm wells? What will the effects be on people and livestock using this water? What alternate source of water could or should be made available?

E. Reclamation

The necessity for land restoration, the process of bringing land back to its original condition after surface mining, was not recognized as a priority in the early years of surface mining in Great Britain and West Germany. Increased surface mining activities in the early post Second World War years brought about a change in the philosophy regarding land restoration. This change in philosophy was prompted by two factors, the loss of agricultural productive land, and vocal public concerns regarding unsightly expanses of landscape near populated communities.

Land restoration was not considered to be economically feasible in the early years of surface mining activities. Token attention was given to restoration work. Updating and introduction of legislation, with bond requirements included, hastened the change or adjustment in priorities. The changes were also made with the knowledge that the sale price of coal mined had increased, and the demand for agricultural land mined and restored had increased as well.

Initial restoration included establishment of forestry areas along with wild life habitats and recreational areas. Changes in legislation required operators to develop better land restoration programs. The bonding requirements were strict enough to encourage surface mine contractors to work with research authorities and local groups and develop programs that would be acceptable to most groups and people. Restoration costs were attached to the value of the resource mined rather than to the agricultural productivity capability of the surface of the land restored.

Land restoration or reclamation in the U.S.A. on a national basis was a requirement of legislation passed in Congress in 1977. Individual states were responsible to supervise the reclamation work within the guidelines outlined in Public Law No. 9587. Many states upgraded their own legislation to meet or improve on federal requirements.

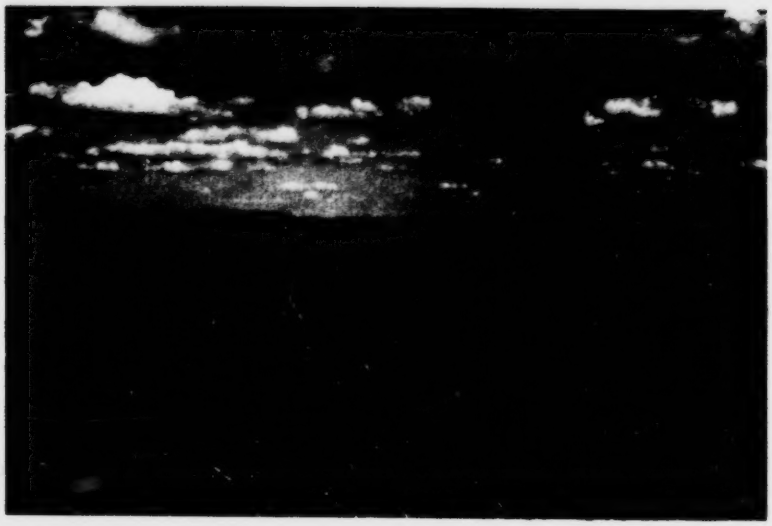
The costs of reclamation vary in different countries and between different states or provinces within countries. Costs can often vary between mine operators in the same general area. Some mining companies appear to have different mining plans in the same general area as well. Costs can vary between surface mining sites or even within areas on one large mining site. Reclamation costs are hard to document. Some companies include mine development costs as a cost of reclamation. Other companies have their reclamation work done under contract. Costs quoted from many different areas and mine operations varied from $1,000 per acre to $22,000 per acre. The average costs quoted in North Dakota and Montana ranged from $4,000 per acre to $6,000 per acre.

Legislation requirements can have an effect on reclamation costs. Type of vegetative cover required can be a cost factor, e.g. native grasses versus cultivated grasses. Amount of root zone and top soil can be a cost factor to consider, as well. One inch of top soil requires about 135 cubic yards of soil per acre, while a three foot "topping" would require about 4,840 cubic yards of soil per acre.

Reclamation costs in the Plains Coal Region of Alberta were not available for this study. Alberta legislation is relatively new. The two major surface coal contractos operating in this general area should have reliable information available once they have had an opportunity to change their mining plans to meet the legislative requirements to save the top soil and meet the primary objective of the Alberta Coal Development Policy which is "TO ENSURE THAT THE MINED OR DISTURBED LAND WILL BE RETURNED TO A STATE WHICH WILL SUPPORT PLANT AND ANIMAL LIFE, OR BE OTHERWISE PRODUCTIVE OR USEFUL TO MAN AT LEAST TO THE DEGREE IT WAS BEFORE IT WAS DISTURBED".

Surface coal mining is only one of the many industries or activities making demands on our agricultural land base. A communication from the Energy and Resources Conservation Board in December, 1980, indicates that approximately 133,000 acres of land had been disturbed in the time period from January 1, 1975 to October 31, 1980 for oilfield activities. Needless to say, this acreage along with land utilized by oilfield activities since Leduc No. 1 blew in 1947, is lost to production until the lease areas are restored to productivity some time in the foreseeable future. (See Appendix)

Information received from Alberta Transportation indicates that 92,644 miles of roads are using 869,430 acres of land in rural areas in 1980. The same tables record 10,986 miles of roads in urban areas use 105,465 acres of land (see Appendix), and 84 road interchanges in operation occupy 1,865 acres of land (see Appendix). Recent information from Alberta Transportation also indicates some railroad lines are abandoned or in the process of being abandoned. There were 140 miles of rail lines abandoned in the Province of Alberta before the Hall Commission Report was published in 1977 by the Federal



PATE 1.
Abandoned Railroad Right-of-Way. Reclaimed in 1962. Crop on N.E. 29-46-20-W4M southwest of Camrose. August 1976.

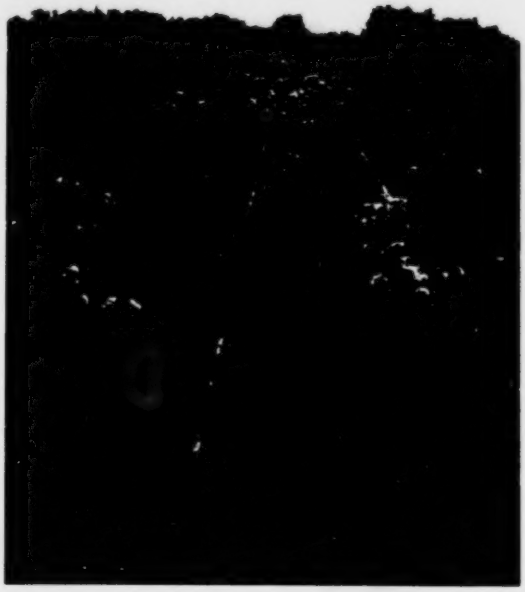


PLATE 2.
Abandoned Railroad Right-of-Way. N.E. 24-48-20-W4M, 8 miles northeast of Camrose. August 1976. Rails removed in 1980.

Government. There has been a further 348 miles of rail lines abondoned since the Hall Commission report was published. Along with the rail lines abandoned to date, there are a further 273 miles in limbo. The future will decide the destiny of these lines. The rail lines tabulated occupy over 9,200 acres of land. Much of it is in agricultural areas. Like many other areas in the Province of Alberta, abandoned rail lines are in evidence in the study area. Some of these rail lines have been reclaimed and are incorporated into adjacent agricultural units. Others lie abandoned and receive periodic attention by regulatory agencies for the control of persistent noxious weeds.

Abandoned county road diversions also persist in many areas of the province. Some of these diversions have been restored to agricultural productivity while others lie idle. There is much that could be done and should be done to reclaim these derelict areas to some use beneficial to society.

Air strips for service centres, sewage lagoons, land fills, gravel pits, pipelines, industrial parks, golf courses and small holdings all make inroads into the agricultural areas. Heavy demands are being made on our land base. Many of these demands are necessary and of a permanent nature. Others, such as surface coal mining, land fills, and some oilfield activities are of a temporary nature.

Provincial legislation recognizes the temporary nature of some activities. This same legislation requires that disturbed land be restored. It is of prime importance for every one to assume their share of the responsibility to assure that the productivity of our soils are restored and maintained for the use of generations to come.

AN OVERVIEW OF SURFACE MINED LAND RECLAMATION IN GREAT BRITAIN

Introduction

The United Kingdom coal industry is one of the largest in Western Europe and one of the most technically advanced in the world.[1] It is one of Britain's biggest nationalized industries.

Recoverable coal reserves in Great Britain are estimated to be 45,000 million tons which could be recovered using present technology. An estimated 1% of the total, or 450 million tons, could be mined by using strip mining or opencast mining methods. Opencast mining in Great Britain is similar to strip mining as it is known in Alberta.

Surface Mining Development (Opencast Mining)

Strip mining started in 1942 with a two-fold purpose; to produce coal, and to return the land to agricultural use as rapidly as possible. Due to geological distribution of shallow coal reserves, strip mining is concentrated in relatively small deposits in localized areas in Wales, Northern portions of England and Scotland.

The National Coal Board was established following passage of the Coal Industry Nationalization Act in 1946. It became operative in 1947. The Board assumed responsibility for the mining of coal and the restoration of the land after mining. The Opencast Executive was founded in 1952 as a branch or division of the National Coal Board, and it assumed the responsibility for processing applications for the surface mining of coal.[2] Before an application for surface mining of a site is finalized, a thorough discussion is held with twenty or more interested parties, including the Planning Authority, land owners, local administrative authorities and other parties to ensure that all views may be heard. The Opencast Executive must be satisfied that adequate land restoration is assured in the final application before the formal

application is submitted by the National Coal Board to the Secretary of State for Trade and Industry, for consideration and approval. If public interest demands it, a Public Enquiry is held after a 28 day interval for adequate posting and response. A final decision is made eventually. Once approved, the project is submitted to tender for development by the Opencast Executive.

The Opencast Executive has a dual responsibility - "to provide coal to meet some of the nation's needs while at the same time ensuring that they do not destroy the land they are working, but leave for future generations something of which they can be proud of."[4]

Land Reclamation Development

Land Reclamation is known as Land Restoration in Great Britain. The National Coal Board and the Opencast Executive have recognized the necessity to develop restoration practices to keep pace with the surface mining operations being developed as other mining operations are phased out. Records indicate there were over sixty strip mining operations licensed to operate in 1976. The individual projects vary in size. However, if one excluded a very few large operations, the average size would be about 300,000 tons. This size would be considered as being very insignificant by Alberta Standards in 1979.[5]

Land restoration after strip mining for coal was, and is, considered very essential. Initially reclamation standards were far lower than today, and during the war years restoration methods were experimental. The practice to reserve top soil was followed in a limited way. Early restoration practices indicated that grass land started to deteriorate after two or three years of planting.

In early post war years a great deal of practical experience was obtained on which improvements in restoration techniques were based. The Ministry of Agriculture reviewed programs being used and, with other members of a Technical Advisory Committee established in 1948, made recommendations to the Government, which led to the introduction of an improved code of restoration which became effective in 1951.[6]

The general principles of the 1951 code were confirmed after a survey of the results of restoration carried out between 1950 and 1953 under the supervision of the statistical department of the Rothamstead Experiment Station.

Restoration of strip mined land in Great Britain is planned well in advance of the start of any surface mining. The 1951 restoration code was developed further as time progressed. It has remained a fundamental document and utilized by the Opencast Executive when individual site restoration programs are being developed.

Restoration is supervised under very strict guidelines developed within the application, and is completed as soon as possible after mining. Once completed the restoration project is turned over to the Ministry of Agriculture which farms the land for a minimum of five years at the National Coal Board expense.[7] Once restoration is approved the National Coal Board disposes of the land. If leased, the land is returned to the lessor. If owned by the Coal Board, the land is sold.

Summary

Since 1942, over 119,000 acres have been rehabilited and returned to agriculture, forestry, or other use. Whenever possible, restoration techniques are used to remove derelictions or intentionally abandoned sites as well.

The United Kingdom has 45 million acres of agricultural land. One acre in each 2,000 acres is actively used to mine coal yearly. An equivalent acreage is being restored each year.[8] The National Coal Board restoration work is directed towards obtaining arable and grazing land for farming or for some other mutually agreed use.

The 1951 restoration code, approved by the world famous Rothamstead Experiment Station, provides guidelines that are followed when each individual surface mining project is considered initially. The final post mining use is approved before the mining commences. The impressive record of land restoration achieved by the National Coal Board is recognized throughout the world.

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AN OVERVIEW OF SURFACE MINED LAND RECLAMATION IN WEST GERMANY

Introduction

The production of brown coal (lignite coal) has long been an important industry in West Germany. Brown coal mining from shallow mines has been recorded since 1816. Production increased as demands for energy increased. The production of briquettes for domestic heating increased the demand for lignite or brown coal. The manufacture of smokeless briquettes reached a high in 1955 when 61% of the total lignite production was used for this purpose. The balance was burned in thermal power plants. In the early 1970's, the briquette market had declined to about 23% of the brown coal mined.

Records indicate that brown coal production has increased spectacularly from 100,000 tons in 1833 to 8 million tons in 1905. A further annual increase to 90 million tons in 1970 was noted for the Rhineland area of West Germany alone. This increased demand for brown coal prompted industry and government to look at the total situation. The recoverable coal reserves in the Rhineland would be depleted eventually. Reorganization and consolidation of coal mining companies was necessary to modernize their mining operations to efficiently meet the increased demand for coal. The extensive damage from surface mining fostered a growing public awareness of the need to develop better methods of mining coal. This public concern was evident in an area of good agricultural productivity located near a good market for agricultural products, the heavily industrialized and populated Ruhr Valley.

Surface Mining Development - Open Pit Mines

The Rhineland brown coal fields are located in flat plains country in the State of North Rhine Westphalia in Northwest Germany near the Dutch border. The coal fields are located in the most fertile farm country of Germany. The coal fields extend over an area of 1,554 square

miles. 8 to 10 billion tons of the estimated 55 billion tons of brown coal in these fields can be recovered using present day surface mining techniques.

The overburden to be removed from the mining area includes loess top soil, together with up to 650 feet of unconsolidated sand, gravel and clay overburden. The loess top soil is an extremely fertile type of loam, a glacial drift type of soil, often 15 to 20 feet thick which extends over much of this area in West Germany.

Surface mining has progressed since pre-war days from shallow surface mines to large open pit mines that are being mined today. The coal seams vary in thickness from 65 to 350 feet. The overburden can be as much as 650 feet thick. Highly specialized equipment is used to mine the coal. In 1955, bucket wheel excavators to remove the coal from deeper depths were introduced. These excavators can excavate slectively and deliver the loess, other overburden materials and the lignite coal by an integrated coveyor belt system, to points of stockpiling or disposal by private railroad to reclamation areas, and the lignite coal to the briquette factories or to the power generating stations.

Four of six large coal companies operating in 1959 merged to form one company. This company, a subsidiary of Germany's largest electric power utility, uses the expensive and highly specialized equipment to produce 85% of the lignite coal mined in West Germany.

Land Reclamation Development

The present form of the brown coal industry and the adoption of improved land restoration practices in Germany evolved over several decades. Reforestation of disturbed surface mining land areas has been practised since the early 1920's. The practice of restoring land for agricultural use was instituted much later.

In March 1950, the state legislature of North Rhine Westphalia passed Germany's first regional planning law. This law, modified in 1962, established a Land Planning Commission charged with the responsibility

of developing overall guidelines for land use within the state. In April 1950, two additional state laws applying specifically to the brown coal producing areas were enacted. One law for overall planning in the Rhineland Brown Coal area created the Brown Coal Committee to develop detailed plans for mining the lignite resources of the state within the framework and intent of the overall regional planning law. The other state law established a community fund to finance land restoration.

The Brown Coal Committee is composed of 27 members representing a cross section of interests most affected by the impact of the mining operations. These interests include representatives from farm associations, county governments, utilities, brown coal mining industry, conservation groups, regulatory agencies, and state government agencies and the planning commission. The basic responsibility of the committee is to safeguard land areas temporarily used for brown coal mining from long term damage and from being rendered unsuitable for more lasting use.

The Brown Coal Committee assures that the land is restored in such a way as to harmonize with the social, cultural, and industrial interests of the rest of the region. This Committee formulates land restoration requirements based on the future use of the land. These requirements are developed as early as possible to enable the mining company to design its mining operation well in advance of the start of mining. This Brown Coal Committee also acts as a review body of considered proposals for extending mining operations to new land areas and to make appropriate recommendations to the president of North Rhine Westphalia. This Committee considers overall land use, conflicting local issues and coal requirements. The Brown Coal Committee is a powerful force that defines the conditions under which the coal industry must operate. Its existence subjects the coal industry to public scrutiny and has been instrumental in bringing about the conservation practises of the industry.

The State of North Rhine Westphalia and the lignite mining industry have accepted the challenge of finding acceptable solutions to the entire set of social and environmental problems created by brown

coal surface mining. This approach makes it possible to treat the overall problem as a whole rather than dealing with separate aspects of the problem on a piecemeal basis.

Summary

There have been about 40,000 acres (less than 10% of the 620,000 acre Rhineland coal area) disturbed since the turn of the century. About 600 acres of land have been disturbed annually in recent years. Reforestation of restored mining land began in the early 1920's. Restoration of agricultural land commenced in 1970 when 470 acres of mining wasteland was restored to agricultural productivity. Of the approximate 20,000 acres restored, about 50% has been restored to forestry, 38% has been restored to agricultural use and 12% has been used for development of artificial lakes utilized for water supplies and park development. As the mining development progresses northward toward the deeper lignite deposits, more and more land will be restored to agricultural use. The loess top soil is being selectively stripped off, stockpiled, or transported to levelled areas for spreading the ultimate agricultural use. It is interesting to note that the top soil is regarded as a mineral in its own right and must be saved. Surface water is valued as well. It is impounded for use for human consumption and agricultural use where practical. The University of Bonn works in an advisory capacity to the Brown Coal Committee when it develops detailed mining plans for surface mining projects.

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The above listed publications were made available courtesy of the Alberta Environment Library.

AN OVERVIEW OF LAND RECLAMATION IN THE UNITED STATES[1]

Surface Mining Development

Surface mining occurs in all states. It affects a wide range of soils, vegetation and organisms growing within the environment. The acreage disturbed is relatively small. Paone et al. 1974 reported that land utilized by mining from 1930 to 1971 amounted to 0.16% of the land mass of the United States. However, mining is geographically concentrate and this results in intense hydrologic and aesthetic changes in specific environments. These changes often affect an area larger than the area that has been physically disturbed.

As of July 1, 1977, the mineral industry had disturbed 5.7 million acres in the United States.

The percentage of land surface mined by commodity, 1930 - 1971, can be summarized in the following table:

Commodity	Percentage of Land Surface Minded
Phosphate rock	2
Iron Ore	3
Clay	5
Copper	5
Stone	14
Sand & Gravel	18
Bituminous Coal	40
All Other Commodities	13
Total	100

In 1964 an estimated 153,000 acres were disturbed by strip and surface mining. Included in this total was 46,000 acres for coal mining. In 1975 surface mining accounted for 55% of the coal mined. A total of 356 million short tons was surface mined. In 1977 Federal agencies

estimated a total of 47,716 acres would be surface mined for coal. However, a much larger area would be affected because of haul roads, damage to contours, acid mine drainage and other off-site effect.

Land Reclamation Legislation Development

Reclamation of surface coal mined lands began in the Midwest in the 1920's. Independent coal companies, with the encouragement of government agencies, initiated an experimental program to establish quick growth forests on ungraded spoil piles. Naturally favorable clean spoil materials and climatic conditions contributed to successful reforestation efforts in many states with a minimum of material handling expense. As techniques changed, reclamation programs were improved.

Surface mined lands were subsequently reclaimed as pasture and crop lands throughout the Midwest.

These preliminary successes, along with growing concern over the effect of surface mining, provided the motivation for the first state surface mining legislation in West Virginia in 1939. Other states quickly followed; e.g. Indiana - 1941; Pennsylvania - 1945; and Idaho and Maryland - 1974.

Early state surface mining laws varied in requirements. Licenses and permits were required. Performance bonds were posted to assure the minimum reclamation requirements were met. Performance standards varied from state to state. They usually required that mined lands be regraded and that revegetation be attempted. The amount of grading required depended on the use the operator intended to make of the land.

During the 1950's and 1960's the increasing amount of surface mining of coal and growing public sentiment led to the passage of legislation in additional states, and to the revision of many older laws. Greater revegetation efforts and increased water quality control were required. The laws did not require that disturbed lands other than surface coal mines be restored.

As time progressed, several states developed detailed standards for all surface coal mining activities and reclamation practices to minimize the adverse effects of mining. Mining and reclamation procedures were integrated to better achieve a predetermined post mining land use. The concept of mining being a temporary land use gained acceptance.

Not all state programs were similar. The diversity in programs between states led to the passage of Public Law #95-87 in 1977 by the United States Congress.(2) One of the major purposes of this law was to establish a nation-wide program to protect society and the environment from the potentially adverse effects of surface coal mining operations. This law was also designed to increase public participation in the regulation of surface mining operations.

The major thrust of the Act was to encourage each state to develop and implement its own program to meet the objectives of the Act. It is interesting to note that Montana and North Dekota have some very strong reclamation requirements in their state laws.

Summary

In the U.S.A. the coal rights are owned by the Federal Government, by Indian Reserves, and in some instances, by individuals. Surface coal mining is geographically concentrated. Supervision of land reclamation in the U.S.A. is a state responsibility. Each state is required to enact legislation and develop regulations to assure that adequate reclamation work can be done. In earlier years reclamation was minimal. Growing concerns expressed by the public required revisions of mining legislation in some states and passage of new legislation in others.

The United Stated Congress passed Public Law #9587 in 2977.(2) This law served several purposes. It encouraged each state to update its legislation andto implement a program to meet the objectives of the Act. It established a nation-wide program to protect society and the environment from the potentially adverse affects of surface coal mining operations. The Act established the legislation and the regulations for

surface coal mining companies to follow in individual states where the local responsibility had not been assumed.

The United States Congress provides funds for State Universities to initiate and develop surface coal mine reclamation research studies.

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AN OVERVIEW OF SURFACE MINED LAND RECLAMATION IN ILLINOIS

Introduction

The State of Illinois is located in the central or midwestern part of the U.S. Prime farm land best suited for producing food, forage, fibre and oilseed crops makes up over 60% of the approximate 37 million acre land base in the state. This farmland has the soil qualities and moisture supply to produce high yields when adequately treated and managed.

The top soil, a loess type of soil, varies in depth from 5 to 20 feet. It is a friable medium textured silty loam with a high moisture holding capacity. The state enjoys a frost free growing season that ranges from 160 to 200 days. Annual precipitation is in the 35 inches to 45 inches range. The climate is of the continental type with hot summers and cold winters. The average annual temperature ranges from 46° F in the north, to 60° F to the south. The winter low temperature is in the 22° F to 25° F or -5° C to -4° C range.

Surface Mining Development in Illinois

The first commercial surface mine in the United States was opened near Danville in East Central Illinois in 1886 when horses and scrapers were used to remove coal deposits covered with shallow overburden (Anon 1972a). The progressive development of larger and more efficient equipment such as giant shovels, draglines and excavating wheels, greatly expanded the surface mining industry. This industry is now operating in west central and southern Illinois where the bulk of the coal reserves are located. Surface mining is now a major method of removing the coal which is a primary source of electrical energy in Illinois and the United States.

The Soil Conservation Service of the United States Department of Agriculture estimated that some 400 million tons of lignite and

bituminous coal would be mined in 1977 in the United States. At the same time an estimated 30 million tons of bituminous coal would be mined in the State of Illinois. This Illinois coal would be recovered from seams with an average thickness of 3.4 feet under some 4,900 acres of prime agricultural land.

The high sulphur content bituminous coal mined in Illinois is blended with a low sulphur content coal shipped in from Wyoming before being utilized in the local power generating stations. Some of the Illinois coal with a high sulphur content is used in plants outside the State where environmental controls are less strict. The sulphur content in Illinois coal can be as high as 7% while Wyoming coal sulphur content is in the 0.3 - 0.5% range.

Strippable bituminous coal reserves of Illinois (seams 18 inches thick and less than 150 feet below the surface) are the largest of any state (Simon & Smith, 1968). There is an estimated 19 billion tons of coal underlying 2.3 million acres of Illinois land.

Land Reclamation Development

The first operational reclamation law in the State of Illinois became effective on January 1, 1962. This act was passed due to increasing concerns for the environment and demands by the public. Any reclamation done previously had been limited to "striking off" or levelling the peaks of the spoil piles by running a bulldozer along the ridges. Vehicle access was difficult to aerial seeding of the spoils with various species of grasses and legumes was done. Resultant growth could not be harvested. After January 1962 all affected land to be used for crops had to be graded to the extent that farm machinery could be used.

The 1962 law was amended in subsequent years. Various interest groups were not satisfied with reclamation requirements or results and insisted on more restrictive legislation. The Surface Mined Land Conservation and Reclamation Act became effective in September 1971. This law had more stringent requirements for permit fees and

bonds, grading, revegetation, acid drainage, gob and slurry disposal, and access. The law also required that with each application for a mining permit a detailed description of the mining proposal be prepared and submitted along with a conservation and reclamation plan. The detailed description of the proposal also had to include statements of ownership of minerals and the land, character and composition of the vegetation and wildlife, current and past uses of the land, mining techniques, locations and names of all streams, creeks, bodies of water and underground water resources. The law also required that the proposed conservation reclamation plans and maps must be made available for public inspection and consideration by the county board having jurisdiction over the land to be affected.

An extensive survey was initiated by the Southern Illinois University with funds provided by the Illinois Department of Mines and Minerals in 1970. The purpose of the study was to conduct an extensive survey of the present status and quality of Illinois surface mined lands and to provide information for future use. The specific objectives of the survey were to:

(1) tabulate the acreage stripped as of June 30, 1971 and classify the acreage into groups, e.g. surface ownership, companies that mined the land, location of the affected areas geographically;
(2) define the location of problem areas;
(3) store data for rapid retrieval;
(4) provide benchmarks for future research.

As of June 30, 1971 some 163,643 acres had been stripped mined. 103,181 acres had been stripped mined prior to 1962 when the first reclamation law had been proclaimed. A further 60,642 acres had been surface mined by June 30, 1971. The survey indicated that surface mine activities disturbed approximately 7,000 acres per year. A further 7,858 acres, although not mined, had been affected by external erosion, water ponding slurry pits, gob piles and tipple areas.

40 of the 102 counties in Illinois had surface mined coal operations. Areas within counties exposed to mining varied from less than 1% in 28 counties to greater that 7% of the land affected in two

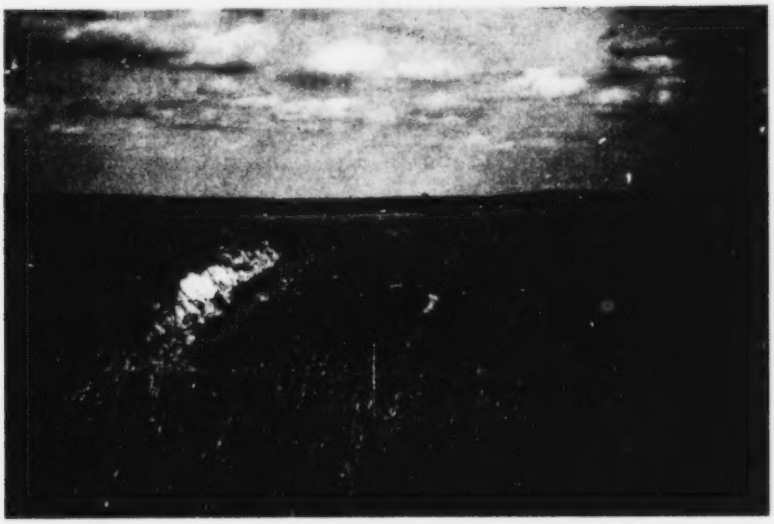

PLATE 3.
Erosion problems in Mid Western Illinois. East of Galesburg. No reclamation.

PLATE 4.
Abandoned gobpiles in Southern Illinois.

counties, Fulton and Perry. The land is classified as prime agricultural land.

Ownership of the strip mined land was listed in five categories:

Land companies	50%
Private or family groups	28%
Miscellaneous Corporations	11%
Recreational Groups	6%
Others	5%

Reclamation of surface mined land was minimal to nil in pre law days. The 1971 study indicated that 'No Utilization Observed' was the largest category of 47% or 76.533 acres. The bulk of the surface mining was being carried out by seven major coal companies operating 34 active operations in 16 counties.

The survey indicated that the counties where the largest amount of surface mining activities were concentrated were concerned about the loss of revenue to the counties from the mined land. The farmers and others were very vocal about the lack of reclamation being initiated. The concerns expressed also addressed the contamination of non-mined areas, watercourses and streams by runoff from slurry ponds, gob piles, erosion etc.

Alternate land use of abandoned or derelict mined areas was being studied.

Summary

The industry is concentrated in west central and southern Illinois where the bulk of the coal is located. The surface land, above the coal, is classified as prime agricultural land.

Upwards of 7,000 acres are disturbed annually to mine the coal. A 1970 study indicated that 47% of the land disturbed was abandoned or classified as 'No Utilization Observed'. The majority of the surface mined land is owned by coal companies or affiliates. Land owners and

other members of society are very vocal about the lack of land reclamation. Administrative personnel in some counties are concerned about the loss of tax revenue. Some concerns were expressed to me about the contamination of non-mined areas, watercourses and streams by acid run-off from ponds and gob piles, etc. Since Public Law #95-87 was passed by the 95th United States Congress in 1977, the coal mining companies, working in cooperation with the Universities in the State of Illinois and State agencies, have commenced some very promising looking reclamation programs. The involvement by the Universities has appeased some of the discontented members of the public.

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AN OVERVIEW OF RESEARCH PROJECTS STUDIED AND SITES VISITED IN NORTH DAKOTA, MONTANA AND WYOMING

INTRODUCTION

The North West area of Northern Great Plains of the United States was chosen for further more detailed studies for a number of reasons. These included similar climate and rainfall patterns; similar soil problems (excess sodium and salinity) to those in the Planning Commission area and the degree of advancement of their reclamation laws. Mines and reclamation research were studied closely in North Dakota, Montana and Wyoming.

Coal mining started in these states in the late 1800's, however, reclamation did not begin until the late 1960's. Because most of the land that is underlain by lignite and sub-bituminous coal deposits is either cultivated crop land or range land, the main thrust of the research was directed to the restoration of the agricultural capability of these mined areas.

This chapter will explore the composition of these research efforts and give a brief overview of the accomplishments and problems that are noted on visits to the area in 1976 and again in the spring and summer of 1979.

NORTH DAKOTA

Research in North Dakota is conducted mainly by three groups: The United States Department of Agriculture (Federal), North Dakota Agriculture Experimental Station (North Dakota State University) and private coal companies. The Federal effort is centered at the Northern Great Plains Research Centre at Mandan, while the North Dakota State University is headquartered out of Fargo. Other agencies involved in the research effort include the U.S. Forest Service, soil Conservation

Service, Environmental Protection Agency and the Office of Surface Management. All of these agencies have supplied staff and funding to various research projects.

The climate at Mandan is of the continental type with hot summers and cold winters. It is referred to as cool, temperate, semi-arid climate. The average precipitation amounts to 16 inches yearly with approximately 12 inches coming during the months of May to September.

The research being conducted at Mandan is with three major objectives in mind. The first involves premining study and mapping of environmental, surface and sub-surface soil characteristics. The second involves ranking these characteristics in order of the degree of problems that they would cause to the re-establishment of agricultural crops. The final one concentrates on eliminating or circumventing these problems by changes in new mining technology or by new soil and crop management practices.

To meet these objectives there are presently seven factors under study. They are: Pre-mining Characterization; Physical Factors, Water Storage, Soil Erosion and Land Stability; Sodium and Salt Related Problems; Chemical Reclamation when Non-Sodic Spoil is not available; Covering Spoils with Soil Material; Plant Nutrient Deficiencies and their Correction; and Vegetation Establishment and Utilization.[1]

Pre-mining characterization allows for the recognizing of problems and planning methods for dealing with them before surface mining begins. Such a study involves an evaluation of soil and overburden characteristics both physical and chemical, surface and ground water hydrology, and an ecological study of plant and wildlife present.

This study is important as it provides the baseline against which the subsequent success of reclamation is measured. Once the overburden characteristics are known, it is much easier for mining engineers to design stripping methods making successful reclamation much easier.

Probably the most important research being conducted here is the soil and overburden characteristics study. By looking at pH (acidity-alkalinity), S.A.R. (Sodium Asorption Ratio - a method of measuring the amount of sodium present in the soil), E.C. (Electrical Conductivity -a method of measuring the amount of total salts in the soil), and particle size and type, many problems can be foreseen. Once known, these potential problems can be reduced and managed or even eliminated.

Problem materials are usually those with fine textures with a high percentage of 2:1 expanding clay minerals (smectite (montmorillanite) and vermiculite), high S.A.R. values, moderate saline conditions and low organic matter contents.

Reclamation success at sites where sodic spoil materials (fine textured) are present near the surface is potentially low, whereas success is potentially high where a thick layer of glacial till, loess, or alluvium overlies the shale materials."[2]

Once the land surface has been restored several more problems can occur. These are erosion, land stability and lack of water storage. Because all natural plant cover has been removed, the land is very susceptible to erosion by wind and water. The degree and length of slope on ungraded spoil piles or on regraded spoil piles covered with respread topsoil has a direct effect on soil erosion. Soil losses exceeding 95 tons per acre from bare sandy loam topsoil on a 400 foot long, 16% slope have been measured.[3]

Another type of erosion is called piping. Piping begins with water starting to work down through surface cracks carrying sediment with it. It is most prevalent on non-covered highly sodic mine spoil. Depending on the underground structure, the hole may range from one-quarter inch in diameter to a cavern large enough to trap a tractor or a half ton truck.

There can also be a problem with surface subsidence once the spoils are leveled. If the spoil pile is leveled during the winter, large lumps of frozen spoil may be present. Once lumps break down and

cavities start to fill, a noticeable slumping or depression can be seen on the surface. This generally occurs 2 to 3 years after the spoil piles have been leveled and topsoil applied. It leaves a depression where water collects, and due to the high sodium soil, remains. Correction involves scraping away the topsoil, adding more spoil and replacing the topsoil.

The other problem that may occur is the lack of water penetration into sodic mine spoils. Since high sodium clay soils tend to seal off, little water can penetrate the surface and be stored for plant growth. Therefore, adequate topsoil material must cover the spoil to provide sufficient water holding capacity.

The amount of sodium and salt in the spoil material are two problem factors that must be taken into very careful consideration when assessing the suitability of mine spoil for reclamation purposes.

Sodium or sodicity is more familiar to Alberta farmers as solonetz or hardpan soils. Sodium causes a problem because of its physical effect on soil or spoils. When sodium is present in the spoil, it can migrate upward into uncontaminated topsoil causing growth problems after several years.

Preliminary experiments started in 1970 show that on highly sodic mine spoil covered with 12 inches of topsoil gave good production for the first year. Over a three year period, production of crested wheatgrass was highest in the first year and declined thereafter. A five year study of these soils showed an increasing amount of sodium at the 6 to 12 inch zone.[4]

To study the importance of thickness of topsoil covering mine spoil, Sandoval and his coworkers established a wedge experiment in which topsoils and subsoils were placed in thicknesses ranging from 0 to 7½ feet over mine spoil. Next topsoil was spread on this wedge at a depth of 0 inches, 8 inches, and 24 inches. These experiments found that yield increased as total topsoil plus subsoil thickness increased up to approximately 30 inches. Beyond this there was little or no

PLATE 5. (start) PLATE 6. (advanced)
Piping erosion observed in reclaimed sodic spoils with no topsoil applied. Mercer County, North Dakota.

PLATE 7.
Reclaimed mine land near Stanton, North Dakota. Ready for topsoil.
July 1979.

increase in yield. Maximum yield depended on the topsoil treatment, with the highest for the 24 inches of topsoil and lowest for the 0 inches.

"The initial results suggest that after about 3 feet, not much additional reduction in total sodium content resulted by covering sodic spoils with greater quantities of soils. These results are preliminary and the long term sodium content in the various layers is unknown."[5]

The effects of salinity are physiological and affect the ability of the plant to take in sufficient water for its needs. Much work has been done on determining the effects of salt on crops and on establishing the relative tolerance of these crops to salinity. However, Power reports that under semi-arid conditions, the salinity stresses may be increased due to the effects of droughts on the plants themselves.[6]

Research has shown that sodic spoil can be chemically reclaimed. Work has been done at Mandan on the use of chemicals such as lime, gypsum or sulfur. It appears that these are relatively slow in action due to their low solubility. They may have a place in that they seem to slow the upward migration of the sodium in the soil. Highly soluble calcium salts such as calcium chloride are expensive but their action on the spoil is rapid and effective. These results are most applicable in areas where there is little or no topsoil to cover mine spoil.

The replacing of the soil material over the regraded spoil has considerable importance in North Dakota. The Surface Owner's Protection Act requires two important things. One, that the soil material be taken in two lifts and stockpiled; and that the soil taken from land of one owner cannot be respread on the land of another. Work done at the Indianhead mine shows that there is little reason to be concerned about the chemical deterioration of these materials while stockpiled.[7]

At the present, it seems that if the spoils are covered with between 30 and 36 inches of soil material (both topsoil and subsoil), the maximum crop yields are obtained.

A word of caution here however. These yields must be regarded only as initial yields. The question is whether they can be maintained at this level which may be greater than or equal to yield obtained on undisturbed soil. The reason is, the replaced topsoil may deteriorate in quality due to upward salt movement over a period of years. A period of 10 to 20 years or more of careful monitoring will be required before it can be said the yield is sustainable and the reclamation a success.

The final test of reclamation will be the vegetation grown on the reclaimed land. It is the author's observation that the revegetative work that was being done at Mandan, the majority appears to be concentrated on grasses, legumes and other native vegetation.

There is presently little work done on cereal grains or other crops. This seems strange as the area near Mandan is approximately 50% cultivated (cereal crops) and 50% grazing. Two sites were observed on which cereal crops such as wheat, corn and barley were grown in small research plots alongside small plots of grasses such as the wheatgrasses and brome. The research people do not report any field size plots being developed to more fully explore the adaptability of these reclaimed spoils to cereal crop production.

The emphasis on forages may be due to the requirement of the North Dakota Surface Reclamation Act and the United States Public Law #95-87 to have the reclaimed spoil established in forages before the mining company can apply to have the bonding period begin.

Since it does not necessarily follow that if land can grow grass then it can grow grain, much more study needs to be done to determine the adequacy of this land for cereal crop production.

The State of North Dakota is bound by the United States Public Law 95-87, which regulates Surface Coal Mining and Reclamation Operations as are all other States in the United States.[8] The Act is an 87 page document which outlines areas covered by the act. However, the regulations to carry out the purposes of the act are enclosed in a 561 page document which outlines exactly how mining and reclamation are to be

carried out. To take precedence State regulations must at least meet or exceed these Federal regulations. Because Federal regulations are written for all areas of and conditions, this can create some difficulty on a state level.

North Dakota has a number of acts relating to coal mining. Two that are of significance are the Surface Owner's Protection Act and the Surface Mine Reclamation Act. The State has given the highest right to the surface owner and the coal company cannot acquire ownership of the land.

The Surface Owner's Protection Act gives the surface owner annual payments for loss of production until the land is reclaimed to the required level of productivity. It also requires the mine operator to move at his expense or buy at fair market value the farm buildings once the operation comes within 500 feet of them. The mine operator is also required to pay the entire cost for the surface reclamation.(9)

The Surface Mine Reclamation Act regulates the surface mining of coal and the reclamation of the mined lands. It provides for a division of the Public Service Commission to oversee the workings and regulations of this act. It can designate areas as being unsuitable for surface mining operations, terms and requirements for permit applications, terms of performance bonds, standards for environmental protection and enforcement procedures as well as other areas.(10) This act has been updated as soon as new information has become available thus keeping it as current as possible with the latest research findings.

MONTANA AND WYOMING

As in North Dakota, research on reclamation has been done by the Universities, Federal and State institutions and the private coal companies. This research has also lead to the development of stringent surface mining reclamation laws.

However, in Montana and Wyoming there is a different philosophy of reclamation in that land has as its ultimate final use either grazing

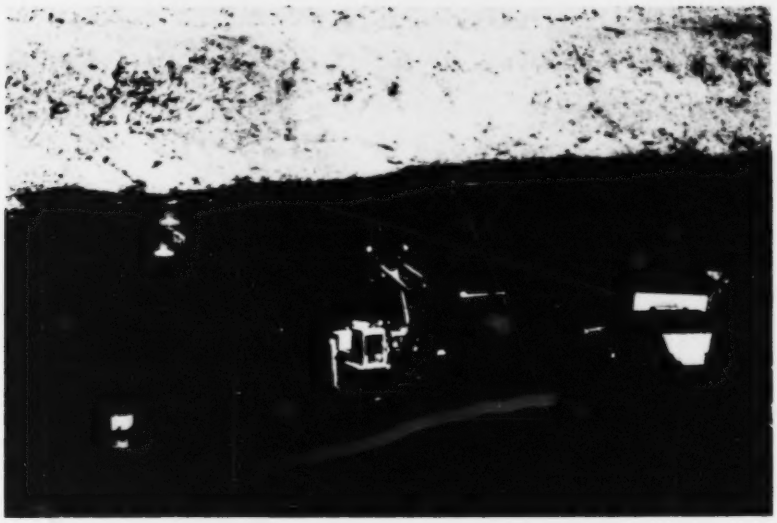

PLATE 8.
50 foot coal seam at Decker's Mine in Southeastern Montana. May 15, 1976.
90 to 100 foot overburden.

for domestic livestock or the provision of habitat for native wildlife. It is to this effort that their reclamation work is being directed.

In 1968 the Montana Agricultural Experimental Station, a division of Montana State University, started revegetation research at Colstrip, Montana. This first research was very basic in nature and looked at varieties of plant materials that would work in revegetation as well as methods of establishing these varieties. Studies have further progressed to look at slope leveling, fertilization and topsoil salvaging.

Present State Law and Federal Law requires that the topsoil and subsoil be stripped and stockpiled separately. Once the spoil piles have been leveled, the subsoil and topsoil are replaced and revegetation starts. In Montana and Wyoming the coal companies must revegetate to native species.(11) Some of these native species are regarded as noxious weeds, and the State has spent millions of dollars in attempting to control them on private or state lands. It is with some degree of bewilderment that as well as ranchers, the coal companies see themselves as being required to re-establish these weed species.

The area around Colstrip, Montana receives between 15 and 16 inches of annual precipitation with most of that coming in May and June. Thus, in revegetation, moisture is not a limiting factor; however, the timing of the seeding to coincide with moisture is most important.

In contrast to North Dakota, the surface is owned by a corporation, Burlington Northern Railway. The farmers and ranchers in the area have agricultural leases on this land. The Coal Company (Western Energy) has a temporary mineral lease on it for the duration of the mining period.

Much work has been done with regard to native seed types and specific mixes for specific slopes and aspects. It appears that each company or each individual has developed a specific native seed mixture which is suitable to local conditions. DePuit reports on recent work done by Montana Agricultural Experimental Station in seeding rates and mixes of certain sub-species.(12) He found, however, problems with

certain dominant species; native cool season grasses tended to be taking over from warm season grasses. Further work is being carried on to establish proper mixtures and seeding rates to correct this problem. As the coal company is required to re-contour the land, work is being done in moving native grass sod plus trees and shrubs on to stream bottoms and banks to speed the revegetation of this area.

There are no problems with sodium or salinity in the spoil; however, the parting or the spoil beneath the first coal seam has a high amount of sodium and salt in it. This will be a reclamation problem when the second seam is mined. There appears to be no problem with subsidence or piping.

The Decker Coal Company operating out of Sheraton, Wyoming was visited. It was found that this area has sodic spoil material. Topsoil averages 1½ to 2 inches. The area received 12 inches of precipitation a year, primarily during the spring rains. Thus, piping is not a problem, however, subsidence is.

As in Montana, the importance of seeding at the right time of year is very important. Here again the problem was noted with establishing weed plant on range before bond would be released. It was felt by the reclamation specialists that the Federal law is good; however, the regulations are counter-productive. It was felt that the end requirement should be stated and that the coal companies or the mining companies be allowed to devise their own means of obtaining these goals.

RECLAMATION COSTS

Throughout the tour, the cost of reclamation was discussed. It was very difficult to get exact figures. The reason for this is that the costs of reclamation can be passed on by the coal company to the consumer and it is to their advantage to put as many as possible into reclamation. Depending on who you talked to and whose definition was used, reclamation costs ranged from $500 per acre for ripping subsoil, spreading topsoil, discing, fertilizing, seeding to grass and clipping the weeds; to $22,000 which included initial soil survey, to stripping

topsoil, selective spoiling, regrading spoil piles, respreading topsoil and reseeding and revegetation costs.

The average costs ranged between $4,000 and $6,000 per acre. These costs included a two-lift topsoil stripping and stockpiling program, some recontouring costs, respreading the topsoil and reseeding.

These are costs under American conditions and requirements. In Alberta we will need detailed economic studies to determine actual costs of stripping and reclaiming agricultural land to its former productivity.

SUMMARY

The research on the reclamation of surface mine land done in North Dakota, Montana and Wyoming have concentrated on two major problem areas. The first is the effects of various salts in the spoils and topsoil. North Dakota is the leader here with the U.S.D.A. Research Station at Mandan doing the majority of the work. They have done work on isolating saline and sodic material by capping it with non-saline, non-sodic topsoil at various depths to find the optimum needed depth. Work has also been done on the use of fertilizers and other chemical amendments to help reclaim sodic-saline spoils.

The other area is in the re-establishment of native grasses and other vegetation on mined land. Montana and Wyoming are the leaders here. Much work has been done on selecting proper mixes of native and tame species of grasses and shrub to obtain an acceptable stand of grass and shrubs in order to meet state requirements that the land be returned to its "original" condition.

Repeat visits to the area of the strip mining projects led us to make the following observation. The State legislators looked to involved research personnel from the state universities and research stations for guidance before revising land reclamation legislation.

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AN OVERVIEW OF SURFACE MINED LAND RECLAMATION IN SASKATCHEWAN

Introduction

The Estevan-Bienfait area of South Eastern Saskatchewan is known as the coal mining area of Saskatchewan. Ranching and mixed farming were the predominate agricultural activities developed when the area was first opened up for settlement in the early 1900's.

The soil type and climatic conditions are somewhat similar to those discussed in the North Dakota summary. Soil problems in the area are similar to those observed in North Dakota and to problems that exist in localized areas within the Battle River Planning Commission Region. Soil analysis indicate that excess sodium and salinity persist in much of the soils of the area. The land in the area has been classified as class #5 or marginal land having low agricultural productive value.

Surface Mining Development

Surface mining started in 1928 in the Bienfait area. The lignite coal mined in this area is used for power generation in the local Boundary Dam Power Plant and by power stations and industrial factories in Manitoba and Ontario. Other mines were developed in more recent years to augment the supply of coal needed at the enlarged Boundary Dam Power Plant and to meet the increased demand from other thermal powered units in Manitoba and Ontario, as well as the increased demand from industry.

In the Estevan area there are three companies mining coal. The two major mining companies are privately owned and the third smaller company is part of a Crown corporation, namely, the Saskatchewan Power Corporation. The S.P.C. is developing the Poplar River Mine at the Coronach location south of Moose Jaw and west of Estevan. The coal from this mine will be used in the Poplar River Power Plant which is expected

to use two million tons of coal per year initially when it starts up in the ealy 1980's.

Land Reclamation

Since surface mining began at Bienfait in 1928 approximatley 12,000 acres of land have been disturbed in the Estevan-Bienfait area. The reclamation process has been itiated on some 2,500 acres. There are no plans to reclaim the remaining 10,000 acres at the present time. A proposal for deeper seam mining on some of the abandoned mine area is being considered for the spring of 1980. This reworked mine will be required to follow guidelines proposed by the Saskatchewan Department of Environment.

Surface mined land reclamation was not required in Saskatchewan prior to 1971. In 1971 the Saskatchewan government suggested that reclamation was necessary. The initial reclamation work done by industry was to level spoil piles to 10%slopes or less. The areas were then seeded to grasses and legumes for wildlife use or livestock pastures. The success of the establishment of the grass and legume stands has been directly related to the characteristics of the levelled spoils. Results have been variable. Shallow mined areas with favorable overburden have responded with acceptable stands of grasses and legumes. In deeper mined spoils successful establishment of forage mixtures has been poor due to the presence of excess sodium (S.A.R. values of 25.$^{+}_{-}$).

Summary

Any surface mine reclamation done in the Estevan-Bienfait area has been done with the initiative of the mining companies involved. Legislation or guidelines requiring land reclamation are awaiting approval. Since there was not any requirement for selective sorting of top soil, reclamation results have varied. Much work has been done by trial and error. More recent strip mine reclamation work looks more promising. One area that was levelled had one cereal crop grown in 1978 followed by a sweet clover crop to be worked in as a green manure crop in 1979. The Canada Agriculture Research Station at Swift Current provides information

on recommended forages. The Federal P.F.R.A. - Indian Head Tree Nursery has established an experimental tree area where several tree species have been planted. Their performance is being evaluated. Cereals planted in the spring of 1979 did not look too good. Germination was poor. The plant growth no doubt was affected by the lack of spring moisture. High sodium levels in the area could also inhibit growth.

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CANADA
Farming areas
YUKON
NORTHWEST TERRITORIES
BRITISH
COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
ST JOHN'S
PEI
CHARLOTTETOWN
HALIFAX
NOVA SCOTIA
VICTORIA
VANCOUVER
WINNIPEG
QUEBEC
TORONTO

AGRICULTURAL LAND AND URBAN CENTRES

An Overview of the Significance of Urban Centres to Canada's Quality Agricultural Land

by

E.W. Manning and J.D. McCuaig

Fisheries and Environment Canada
Lands Directorate

July, 1977

MAP/CARTE 1:

CANADA'S POTENTIAL CROPLAND

LES SOLS OFFRANT UN POTENTIEL AGRICOLE AU CANADA

CANADA LAND INVENTORY AGRICULTURAL CAPABILITY CLASSES 1-3 FOR ALL PROVINCES EXCEPT BRITISH COLUMBIA AND NEWFOUNDLAND WHERE CLASSES 1-4 ARE SHOWN. POCKETS OUTSIDE C.L.I. BOUNDARIES MAY EXIST BUT ARE TOO SMALL TO MAP

LES SOLS DE CLASSES 1-3 A BON POTENTIEL AGRICOLE SELON L'INVENTAIRE DES TERRES DU CANADA POUR TOUTES LES PROVINCES SAUF POUR LA COLOMBIE BRITANNIQUE ET TERRE NEUVE OU L'ON A UTILISE LES CLASSES 1-4. MEME SI CERTAINES ZONES PEUVENT EXISTER A L'EXTERIEUR DES LIMITES DE L.T.C. ELLES SERAIENT CEPENDANT TROP PETITES POUR ÊTRE CARTOGRAPHIEES

AN OVERVIEW OF SURFACE MINED LAND RECLAMATION IN ALBERTA

Introduction

The area of Canada is 2,272 million acres.[1] Two-thirds of the land base is useless for any commercial agriculture due to climate. Of the remaining one-third, the greater part is limited because of too much moisture, rockiness or steepness. Less than ten percent of the land area of Canada or approximately two hundred million acres is potentially useful arable land. 174 million acres have some degree of development. Of this amount, only about 100 million acres is improved land in crops, fallow or pasture. Only about 25% of this area, 24 million acres, is arable land in climatically favored areas. These areas are the same areas where the major metropolitan conglomerates are situated (see map).

The total land area of Alberta is 157,710,720 acres or 6.9% of the land area of Canada.[2] The occupied farm land area in Alberta is 49,928,771 acres or 29.5% of the potentially useful arable land in Canada. It is interesting to note that an estimated 8,000,000 acres of the arable land in the plains area of Alberta are located in the area of coal production potential.[3]

Climate

Climatic conditions in the plains region of Alberta are similar in many respects to the conditions that exist in other regions of the northern plains area. The climate is classified as continental with cold winters and hot summers.

The length of the growing season varies in different regions of the province. It can vary from an average of 75 days in northerly areas and areas adjacent to the Foothills, to over 120 days in areas south of Calgary.[3]

SOIL GROUP MAP OF ALBERTA

MAJOR GROUPS

BROWN SOILS

The Brown Soils occur in the semi-arid short grass prairie section of the province. Orthic Brown Soils have an average of five inches of surface horizon that is brown in colour and contains about two per cent organic matter. The horizon of lime accumulation is at about 15 to 20 inches; this represents the average depth of rainfall penetration. The average annual precipitation in the area is about 12 inches, the yearly total varying from 6 to 26 inches. Moisture is a limiting factor to crop growth and only a few soil types are considered arable. There are about two and one-half million acres cultivated under a dry land agriculture. It is mainly under a wheat-fallow rotation. Half a million acres are irrigated. The irrigation projects lie west and northwest of Medicine Hat and are in the area having the longest growing season in the province. The remainder of the area, nine million acres, is used as native pasture.

DARK BROWN SOILS

The Dark Brown Soils occur in an area that is slightly less arid than the Brown Soil area. Precipitation averages about 14 inches, but varies widely from year to year. Orthic Dark Brown Soils have an average of seven inches of surface horizon that contains about four per cent organic matter. The horizon of lime concentration is at about 24 inches. As in the Brown Soil area moisture is the main limiting factor to crop production and here also a wheat-fallow rotation is almost universal. There are about nine million acres of Dark Brown Soils with about four million cultivated. There are 200,000 acres of Dark Brown Soils irrigated.

BLACK SOILS

The Black Soils occur in areas with a dry subhumid climate; in general the parkland portion of the province. Rainfall in the area varies from an annual average of 15 inches along the southeastern side to 18 inches on the north and west sides. Some frost hazard occurs in the eastern portion of the area and along the western side. The soils in the southeastern half of the area are Thin Black and have an average of five inches of a black surface horizon; the northwestern half are Orthic Black and the black surface horizon averages about 10 inches. The lime concentration horizon varies from about 30 inches in the Thin Black Soils to 48 inches in the Orthic Black Soils. The organic matter in the black surface horizon averages about eight per cent. There are 15 million acres of Black Soils, with 9 million cultivated. There are approximately 50,000 acres of Black Soils irrigated; these are in the southwest corner of the province. A wide range of crops can be grown on the black soil areas and the soil's productivity is generally high.

DARK GREY AND DARK GREY WOODED SOILS

The Dark Grey and Dark Grey Wooded Soils occur in areas with a dry subhumid to subhumid climate and where there is fairly continuous tree cover. The average annual rainfall in the areas varies from 16 to 19 inches and the average frost free period averages less than in the Black Soil zone. These soils usually have a thin leaf mat on the surface. Under the leaf mat is a black to dark grey surface horizon from 3 to 10 inches thick. Under this there is often a very light grey leached horizon. The lime concentration horizon, if present, is generally at 40 to 60 inches below the surface. There are about 10 million acres of Dark Grey and Dark Grey Wooded Soils, a little over four million of which are cultivated. A fairly wide range of crops can be grown and their productivity is generally fairly high.

GREY WOODED SOILS

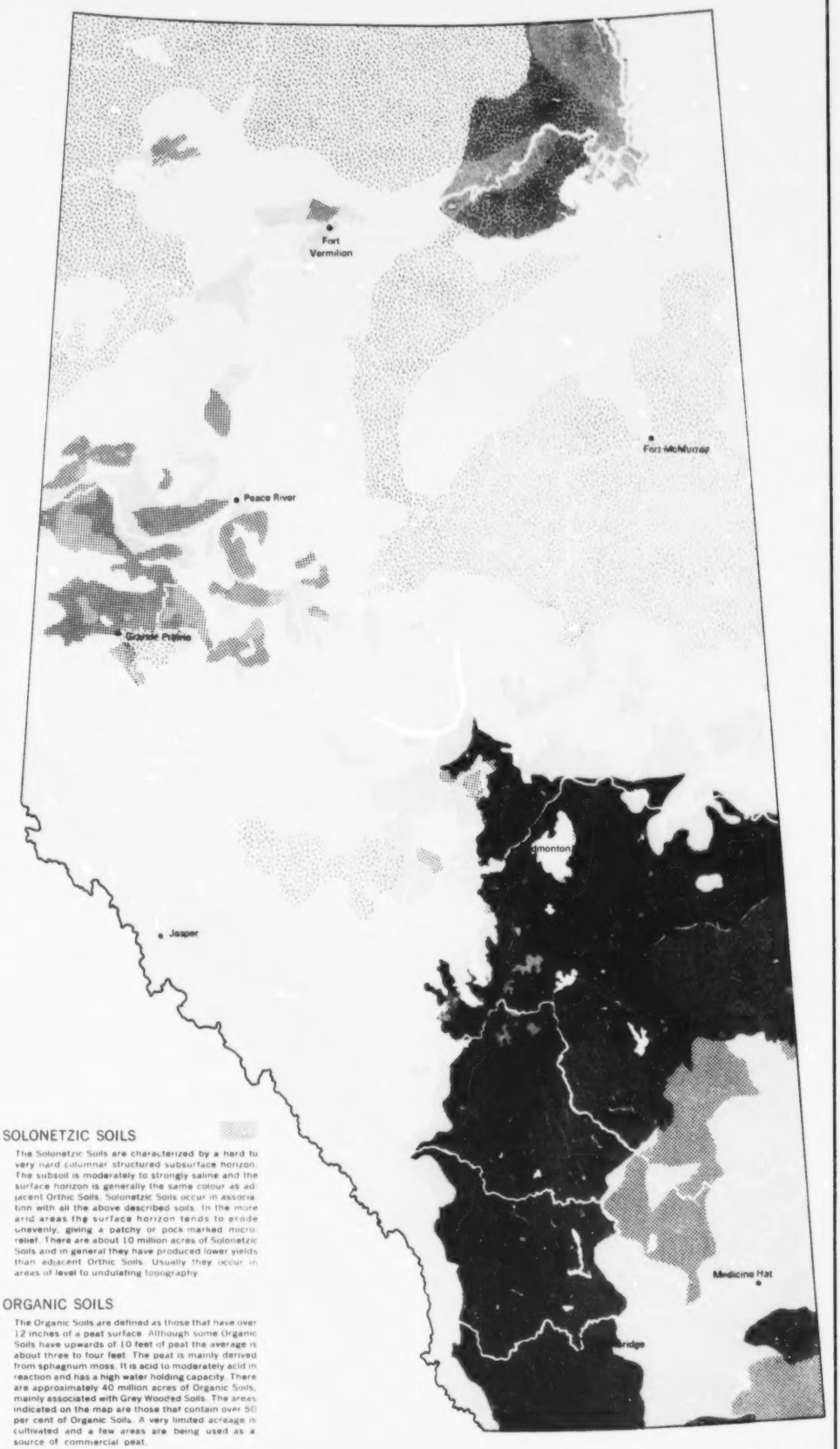
The Grey Wooded Soils occur in areas with a subhumid climate and where there usually is continuous tree cover. Rainfall in the areas varies from 19 to 22 inches in the southwestern portion of the area to 12 to 14 inches in the northern portion. In most of the area frost is a hazard to crop production. An Orthic Grey Wooded Soil is characterized by a leaf mat, a thin dark surface horizon of less than two inches in thickness, a light grey platy structured subsurface horizon and a strongly structured subsoil horizon. These soils are low in natural fertility and respond to the application of mineral fertilizers and additions of organic matter. There are upwards of 50 million acres of Grey Wooded Soil of which about 5 million are cultivated. Coarse grains and hays are the principal crops grown on these soils. Careful soil management is required to achieve good productivity.

BROWN WOODED AND ACID BROWN WOODED SOILS

Brown Wooded and Acid Brown Wooded Soils occur in areas with a subhumid climate and where there is tree cover. In general they are young soils with weak profile development. They are brown to dark brown in colour and there is no clear demarcation between the surface and subsoil. The subsoil is friable and lacks well defined structure. The Brown Wooded Soils are neutral to mildly alkaline in reaction; the Acid Brown Wooded Soils are mildly to moderately acid in reaction. In addition to the area indicated on the map small areas occur throughout the northern and western portion of the province. Very few acres are presently cultivated. However, some areas have arable possibilities.

UNDIFFERENTIATED MOUNTAIN COMPLEX

Limited survey data suggest three divisions: (a) bare rock, mostly steeply sloping, (b) relatively shallow soils on the lower slopes that are mainly Grey Wooded, Podzol, or Brown Wooded, and (c) the bottom lands containing Gleysolic, Organic, and/or Regosolic Soils.



SOLONETZIC SOILS

The Solonetzic Soils are characterized by a hard to very hard columnar structured subsurface horizon. The subsoil is moderately to strongly saline and the surface horizon is generally the same colour as adjacent Orthic Soils. Solonetzic Soils occur in association with all the above described soils. In the more arid areas the surface horizon tends to erode unevenly, giving a patchy or pock marked microrelief. There are about 10 million acres of Solonetzic Soils and in general they have produced lower yields than adjacent Orthic Soils. Usually they occur in areas of level to undulating topography.

ORGANIC SOILS

The Organic Soils are defined as those that have over 12 inches of a peat surface. Although some Organic Soils have upwards of 10 feet of peat the average is about three to four feet. The peat is mainly derived from sphagnum moss. It is acid to moderately acid in reaction and has a high water holding capacity. There are approximately 40 million acres of Organic Soils, mainly associated with Grey Wooded Soils. The areas indicated on the map are those that contain over 50 per cent of Organic Soils. A very limited acreage is cultivated and a few areas are being used as a source of commercial peat.

...d by the Alberta Institute of Pedology. Published by the Department of Extention, The University of Alberta

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The 30 year mean annual precipitation has varied from over 24 inches in areas adjacent to the mountains, to less than 11 inches in localized areas of south eastern Alberta. The mean annual precipitation in most of the agricultural areas of the province falls in the 12 inches to 20 inches range. Approximately fifty percent of the precipitation is usually received within the growing season months of April through August. The Atlas of Alberta also indicates the mean annual snowfall for the 1931 - 1960 period in agricultural areas was in the 30 inches to 75 inches range.

Soils

A. Soil Zones

The soil productive capability in the province varies from soil zone to soil zone. There are six major soil zones in the Province of Alberta.[4]

I. The Brown Soil Zone

This soil zone, located in south eastern Alberta, is often classed as semi-arid due to the limited annual precipitation received, 11 - 13 inches, frequent drought, high evaporation and frequent hot, dry winds. Moisture is the principal limiting factor in crop production. In the normal profile the surface horizon (Ah) is about 5 inches deep and brown in color. This surface horizon is often referred to as the top soil.

II. The Dark Brown Soil Zone

This soil zone is located in a band running from south of Lethbridge in a north easterly direction, through Wainwright on it northern border and Coronation on its southern border to the Saskatchewan boundary. The average annual precipitation is in the 13 - 15 inches range. This area experiences fairly high evaporation with some drought periods. Moisture is the principal limiting factor in this soil zone. In the normal soil profile, the surface horizon (Ah) averages about 7 inches

thick and is dark brown in color.

III. The Thin Black Soil Zone

This soil zone is located in a much narrower band on the western border of the dark brown soil zone. This zone includes the urban centres of Cardston, High River, Calgary, Stettler, along with others within its boundaries. The annual precipitation averages between 14 and 17 inches. Drought occurs occasionally. Soil management could be the limiting factor in crop production in this soil zone. The normal soil profile has a surface horizon (Ah) that averages about 10 inches in depth. The upper 3 - 6 inches portion of this horizon is black in color and the lower portion is dark brown. This soil zone has been referred to as a transitional soil zone between the dark brown soil zone and the black soil zone.

IV. The Black Soil Zone

This soil zone can best be described as an inverted irregular triangle with its apex at the international boundary and its base running in a westerly direction from east of St. Paul to the Westlock, Barrhead area. This zone extends north to west of Calgary, through Red Deer, Wetaskiwin, Camrose and Edmonton extending east through Vegreville to the interprovincial boundary at Lloydminster. Interspersed in this zone are pockets or islands of Dark Grey and Grey Wooded soils.

The annual precipitation in this zone averages between 17 and 19 inches. Droughts are rare. Soils in this zone are the most fertile in the province. The organic matter is much more plentiful in the top soil. The normal profile has a black to very dark brown surface horizon (Ah) that averages 12 - 14 inches in depth. A wide variety of agricultural enterprises can be developed on farms in this soil zone.

V. The Dark Grey and Dark Grey Wooded Soil Zone

This soil zone is located to the west and north of the Black Soil Zone. It extends from small areas located west of Calgary on the

south, to much larger areas bordering on the Black Soil Zone further north and into the Peace River Block and other areas of northern Alberta. The annual average precipitation averages from about 20 inches in the southern areas to 12 inches in the northern section. Availability of plant nutrients and organic matter could be the limiting factor in crop production in this zone. Inclusive of legumes in crop rotations supplemented by commercial fertilizers should ensure more satisfactory crop production. The soil profile is variable in this zone ranging from nearly black to grey. The surface horizon consists of a very thin layer of semi-decomposed leaf litter underlain by a thin topsoil black or grey-black in color over further platy layers of somewhat greyer color. This variation in color in the surface layer is due to excessive leaching and loss of organic matter.

VI. The Grey Wooded Soil Zone

This soil zone covers the vast areas of Northern Alberta stretching from Rocky Mountain House to Edson and Grande Prairie and north east through Athabasca and Cold Lake to the North West Territories. The average annual precipitation varies from about 12 inches in the northern sections to about 20 inches in the southern areas. The temperatures are cooler hence lower evaporation occurs. The growing sections are shorter than those experienced in other soil zones. They can range from 60 - 75 days. The soils are relatively less fertile because of excessive leaching of organic matter and plant nutrients into the lower horizons. The length of the growing season limits the types of crop that can be grown. The inclusion of commercial fertilizers and legumes in the crop rotation can often ensure better crop production. The soil profile may be somewhat similar to that of the Dark Grey and Dark Grey Wooded Soil Zone. However, the thin surface layer may be absent due to excessive leaching that has occurred.

B. Soil Types

The foregoing listed soil zones are indicative of the type of climate one could expect in the area. There are many different soil types classified within these soil zones.

Within the study area the County of Flagstaff includes portions of the Dark Brown Soil Zone in the south easterly area, while the balance of the county is located within the Thin Black Soil Zone. The County of Camrose includes a small portion of the Thin Black Soil Zone while the balance of the county lies within the Black Soil Zone. The Counties of Wetaskiwin and Ponoka lie within the Black Soil Zone except the land areas located west towards and beyond the 5th Meridian which lie within the Dark Grey and Grey Wooded Soil Zone. The quality of the soil within the study area is classified from Class I to Class III in the Dark Brown and Black Soil Zones with the soils in the Grey Wooded Zone classified Class IV and V predominately.(5) In all areas there may be localized pockets of poorer class soil due to erosion, drainage or other factors. Class I soil rating is given the highest growth potential and Class VII the lowest growth potential.

Temperature ranges allow for the production of a variety of agricultural crops. In western extremities of the study area the growing season is shorter. Crops selected for growth and crop management practices need to be managed accordingly. Good management is essential in all areas to get optimum benefits from the land capability.

The main productive soil types in the area were developed on glacial till, on glacial lacustrine deposited material, on alluvial lacustrine deposited material, or on alluvial-aeolian deposited material. These soil types include Angus Ridge loam, Beaver Hills loam, Camrose loam and Wetaskiwin loam, as well as others. Blends of two or more of these different soil types occur in different proportions in the soil profile in different localized areas. Some of the soils such as the Angus Ridge loam and the Beaver Hills loam have relatively good drainage. Others such as the Camrose loam, Killam loam and Wetaskiwin loam range from poorer to fairly well drained soils. While still others such as the Peace Hills Sandy Loam, Ferintosh Sandy Loam, Kavanagh Loam, and Torlea Loam are classified as poorly drained or excessively drained soils. The soil types with the better drainage are usually the more productive soils. Associated with the poorly drained soils are problems of root penetration and water percolation. These problems in turn can cause other problems such as excessive concentration of salts or salinity.

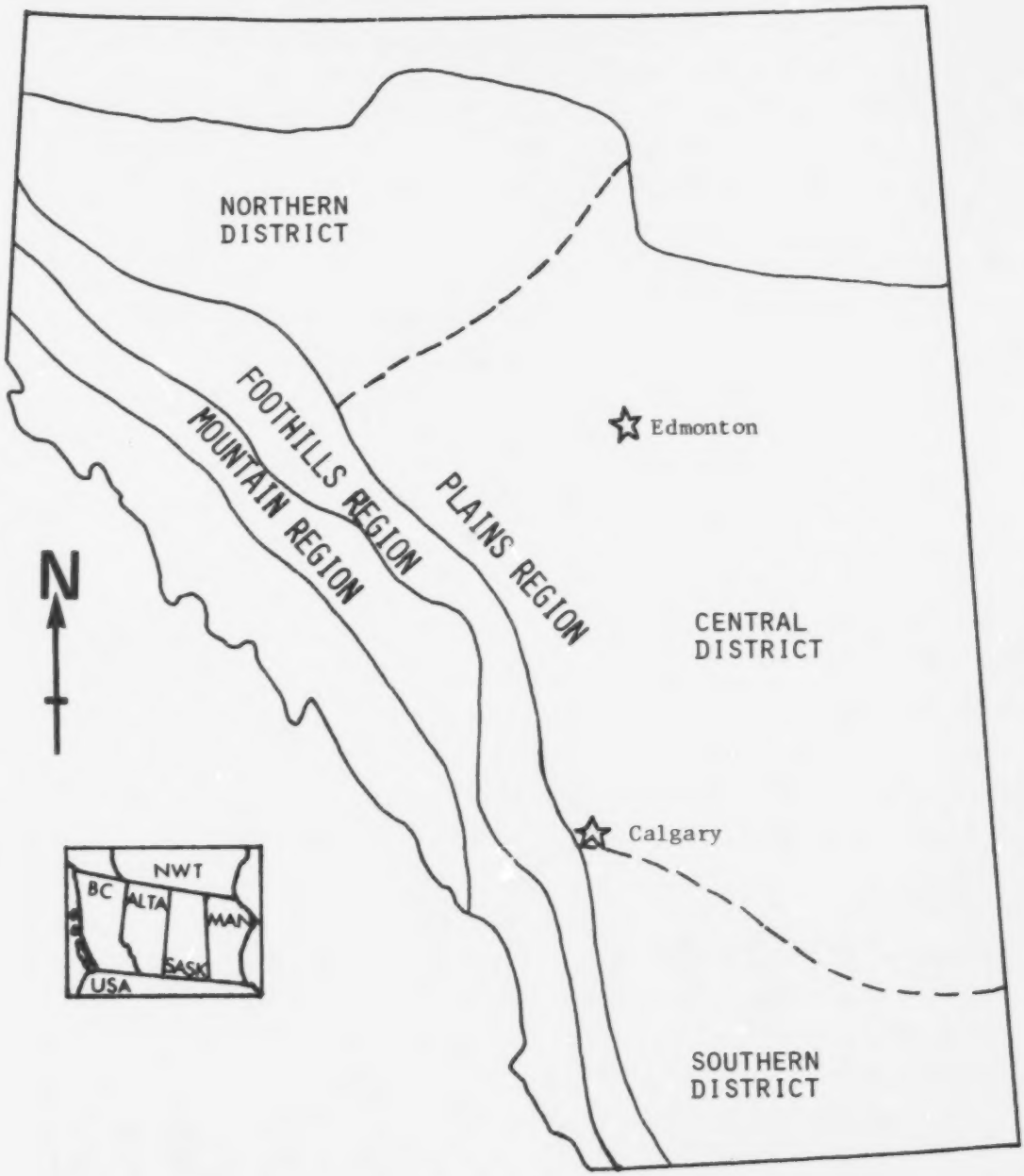

Figure 1 Coal Regions and Districts in Alberta

Ref.: Appendix 4, Alberta Municipal Affairs, January, 1976

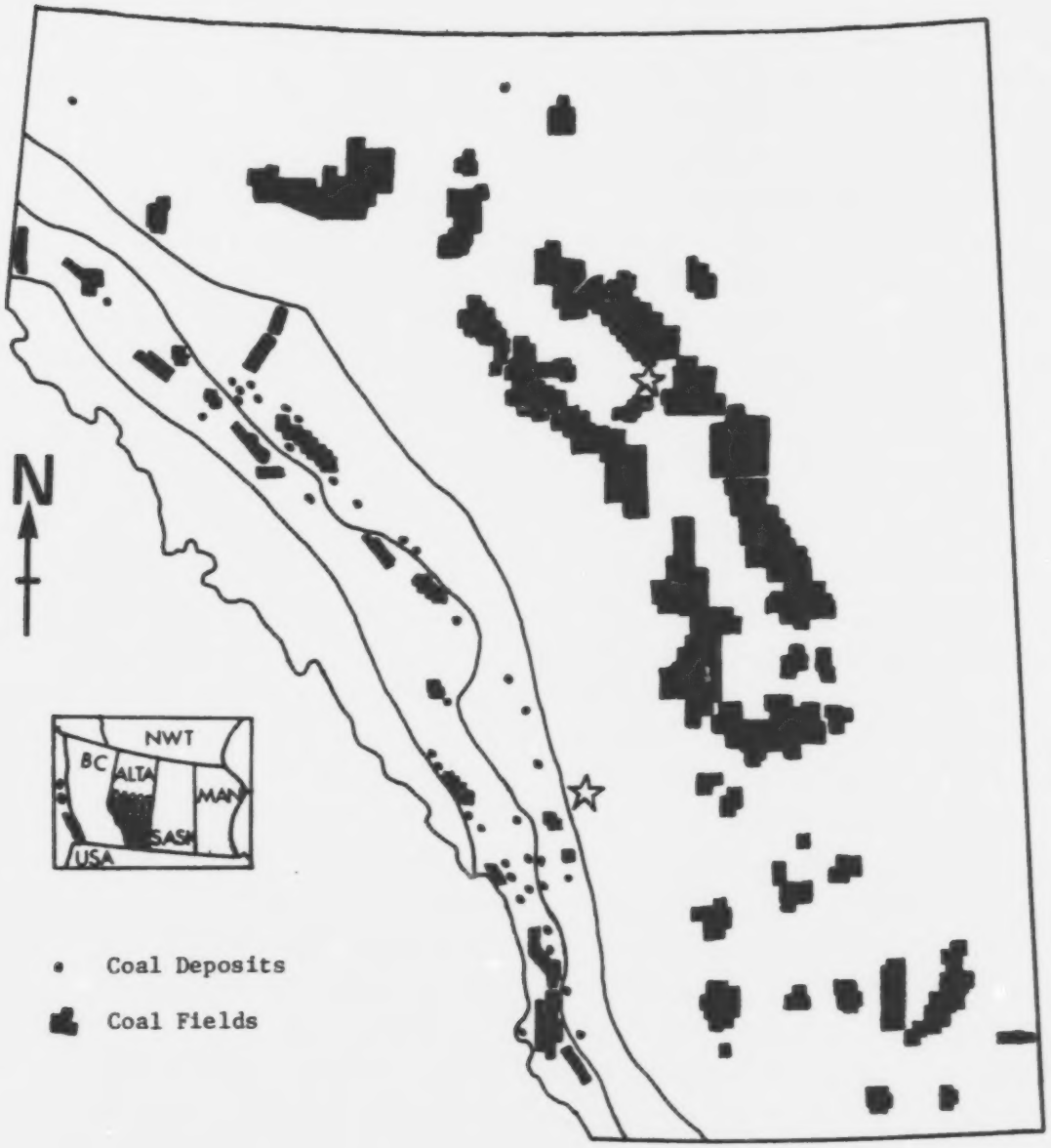

Figure 2 Designated Coal Fields and Isolated Coal Deposits in Alberta

Ref.: Reserves of Coal, Province of Alberta, ERCB, 1978

The problems experienced with agricultural productivity are also problems that should be considered at time of land restoration or reclamation. Proper restoration might alleviate some of the problems while improper restoration could aggrevate or worsen the problems.

A visit to the Calgary Power Whitewood mine reclamation site at Wabamun indicates what the growth potential for legumes in C.L.I. Class III and Class IV rated soils can be after strip mining. Drainage has been improved. The topography has been modified to permit the use of agricultural equipment and minimize erosion. Available organic matter present in the original soil profile has been incorporated with the subsoil to provide a root zone. These modifications along with good management practices should enable the reclaimed spoil piles to produce legume crops unless other unforeseen chemical or physical changes take place in the soil.

SURFACE MINING DEVELOPMENT IN ALBERTA

Development of the coal mining industry on the plains area followed the opening of the west by the railroads. A review of the J. D. Campbell report[6] indicates the first permit for underground mining of coal in Alberta was issued in 1895 when a permit was issued to the C.P.R. for mining in the Lethbridge area. In 1897, permit #4 was issued for a coal mining operation in the Edmonton area. The interest in and need for coal mining developed as the population increased and widely scattered settlements were established.

Underground mining activities in many areas were followed by and consolidated with surface mining activities where practical. This report published in 1964 indicated that 1,759 coal mining permits had been issued for the mining of coal in the plains area of Alberta, of which 310 permits were issued for surface mining of coal.

Surface mining of coal in southern Alberta commenced at Milk River in 1911, Taber in 1913, and at Sheerness, Carbon and Ardley (east of Lacomeb) in 1915. The first permit for surface mining of coal in the Battle River Planning Commission Region was issued in 1910 for a mine

PLATE 12.
Camrose Colleries Mine. 4 miles southeast of Camrose. Mined between 1943-1962. No reclamation - no growth.

PLATE 13.
Camrose Colleries Mine. East of Camrose, north side of Highway No. 13. Water ponding.

development at Dinant, north of Camrose. A permit was issued for a surface mine development near Wizard Lake in 1913. Other developments followed with a permit issued for a strip mine six miles south of Edberg in 1915. The Burnstad strip mine southeast of Round Hill was started in 1917. Other coal mines, both underground and surface, had been issued permits in succeeding years. Some operations were active for longer periods of time than others. Some changed hands or were consolidated with adjacent operations. Some no doubt were abandoned.

Activities associated with the Second World Was prompted an increased demand for surface mined coal. Forestburg colleries, a subsidiary of Luscar Ltd., was issued a permit for surface mining of coal in what is now known as the Diplomat mine, located 10 miles southwest of Forestburg. This mine has been operating since 1949 with an annual capacity of 1 million tons of coal.

Camrose Colleries was issued a permit to surface mine coal at Twomey siding, 5 miles southeast of Camrose in 1943. These were both relatively large operations. The Camrose Colleries surface mine operation ceased operations in 1962. The Diplomat surface mine is till being mined. It is scheduled to be phased out in 1980 when the coal supply is exhausted. It will be replaced by Forestburg Colleries' new Paintearth Mine, south of the Battle River. This new mine is scheduled to become operative in 1981 with a projected capacity of two million tons of sub-bituminous coal per year.

Along with Forestburg Colleries' Diplomat coal mining operations, there are five other large surface coal mining operations active in the sub-bituminous coal bearing areas located in the plains area of Alberta. Manalta's Vesta mine, north of Halkirk, was developed in the mid 1950's to supply coal for the domestic and industrial trade. The bulk of the coal produced now is sold under contract to Alberta Power's Battle River Generating Station located adjacent to the mine site. Manalta's Roselyn mine at Sheerness was developed about forty years ago to supply coal for local use. Increased demand for energy created a market at the Saskatchewan Power Corporation Queen Elizabeth Generating Station in Saskatoon. Further expansion of this mine is planned to

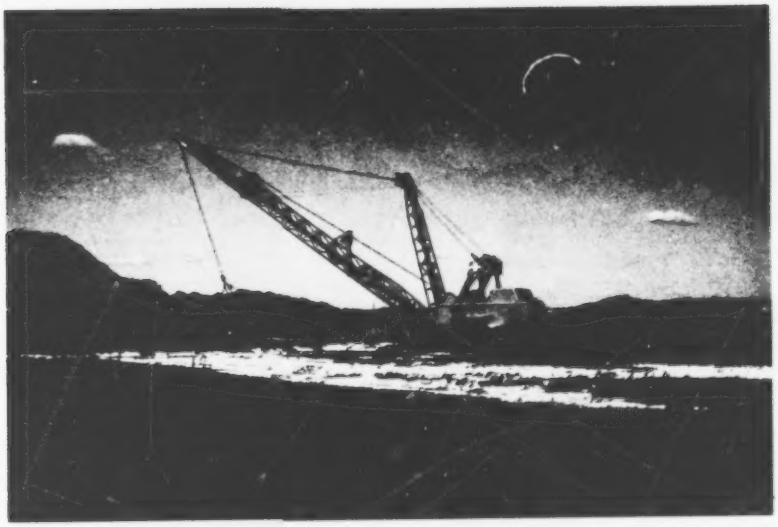

PLATE 14.
Large capacity dragline "Bigfoot" stripping overburden at the Vesta Mine north of Halkirk. October 1980. Near mining site, east side of S.R. No. 855. Alkali soil.

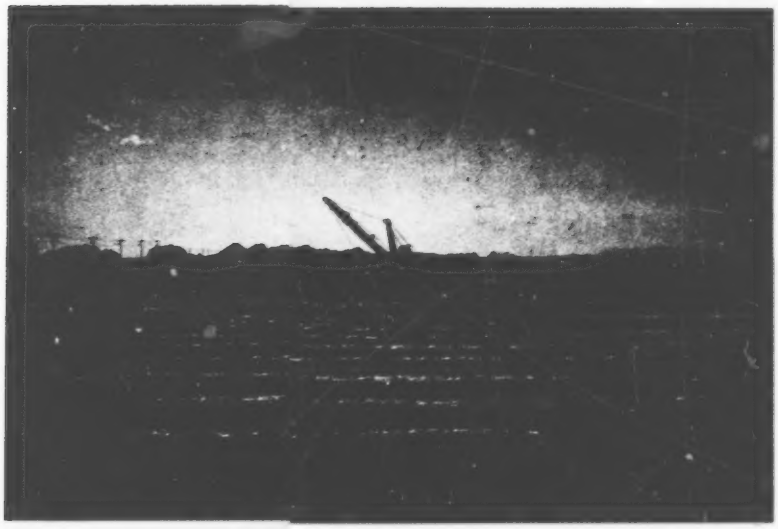

PLATE 15.
"Bigfoot" dragline in background. October 1980. Cereal cropland scheduled for surface mining. Southeast of Bigknife Provincial Park.

PLATE 16.
Barley test plot at Whitewood Mine Site. Summer 1979. Mining and reclamation work in background.

share the requirements for Alberta power's Sheerness Generating Station that has been approved for construction and is scheduled to become operational in the mid 1980's. Manalta also operates the Whitewood mine at Wabamun, which started operations in 1962 along with the Highvale mine at Seba Beach, which started operations in the 1970's. The Whitewood mine yeilds about 2 million tons of coal annually which is delivered under contract to Calgary Power's Generating Station at Wabamun. Manalta's Highvale mine production will be geared to satisfy the demand of Calgary Power's Sundance Generating Station located on the south shore of Wabamun Lake. This plant, when fully operational, will require an anticipated 8 million tons of coal per annum.(7)

More recently Alberta Power has received approval to develop its Sheerness Generating Station adjacent to Highway #36, southeast of Hanna. The coal requirements for this plant, an anticipated 3.7 million tons annually, will be provided on an equitable basis by Manalta's Roselyn mine and by Foresburg Colleries' Sheerness mine operation.(8)

Along with the operations mentioned above, Edmonton Power has received approval for development of a thermal generating plant in the Genesee area. There will be applications processed for development of other potential coal bearing resources of the plains area in the foreseeable future. All of these developments will disturb the agriculture productivity of the specific area. All of them, along with the mining projects already approved, will involve land restoration if the requirements of the Land Surface Conservation and Reclamation Act are to be fulfilled.

SURFACE RECLAMATION IN ALBERTA

Land restoration or reclamation is relatively new in Alberta. Passage of the Land Conservation and Reclamation Act in 1978 established the authority and the responsibility to assure that land reclamation would be accomplished. The Land Conservation Regulations approved in 1974 with amendments up to 1976, the Coal Development Policy for Alberta published in 1976, and the Guidelines for the Reclamation of Land in Alberta Affected by a Surface Disturbance published in December 1977 are

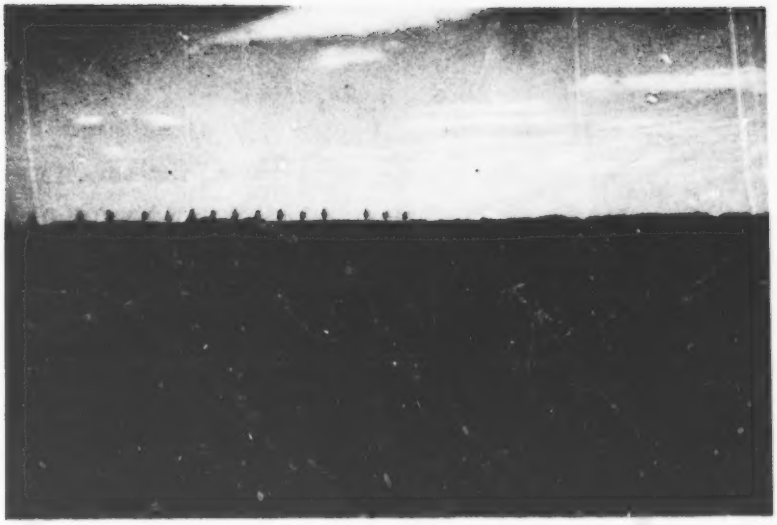

PLATE 17.
County of Flagstaff No. 29. Reclamation Project S.W. 1-46-21-W4M.
East of S.R.#855. Summer 1980.

all relatively new documents. They should be very meaningful and useful when developing plans for the restoration of surface mined disturbed agricultural land.

Prior to the passage of the legislation, restoration of agricultural land was minimal no nil. Any reclamation done usually included "striking off" or levelling the peaks of the spoil piles; planting grass and/or grass legume mixtures and planting some trees. Some surface mining operations have received less attention than the items indicated previously.

There is not information available to indicate how much land was disturbed by surface mining following the issuance of the 300+ permits issued prior to 1964.(6) In 1964 there were 27 strip mines operating in Alberta.(3) Eighteen of these mines were operating north of the Drumheller area. There were 6 strip mines operating within or in close proximity to the Battle River Planning Commission Region. Within the Battle River Planning Commission region, one strip mine liscensed in 1943 and phased out in the early 1960's, is not being utilized. It could be classed as derelict or abandoned land. This land is privately owned hence, it does not meet the requirements of the 1973 Land Conservation and Reclamation Act. When abandoned or derelict mine sites, sewage lagoons, garbage dumps, roads, sand and gravel sites or abandoned properties in many other categories meet the requirements of the 1973 Act, Alberta Environment will initiate reclamation procedures. Since 1975, 905 individual sites ranging in size from one-half acre garbage dumps to abandoned strip mines up to 400 acres in size have been reclaimed at a total investment of over $7 million.(9) There were 94 abandoned mine sites and/or mine hazard sites included in the program at a cost of $1,700,000+ to date. No doubt there will be follow up work needed on some of the reclaimed mine sites.

In 1975 the County of Flagstaff #29, working in cooperatio with Alberta Agriculture and the Forestburg Colleries, and with supp from Alberta Environment, initiated a land reclamation prgram for a parcel of land S.W. 1-41-16-W4M in the mined area adjoining Highway #855.(10) This quarter section of land purchased by the County of

Flagstaff, when levelled and contoured, did not have top soil segregated for post levelling use. Initial reclamation costs in 1975-76 were calculated to be $1,165.00 per acre. Corrective measures carried out in 1977 amounted to a further $115.00 per acre. These measures included ripping to counteract some compaction problems, relevelling in localized areas to correct subsidence, and straw incorporation in an area in the southeast corner of the quarter where poor drainage and bentonite materials inhibited proper crop production practices. See Appendix #3

The 1976 program included planting (i) four 10-acre cereal plots and a series of six 1-acre strips containing a variety of grasses and legumes. (ii) a series of five 10-acre plots of grass legume mixtures with various levels of phosphorus and nitrogen levels applied. The cropping program has been carried out annually with modifications. Results are summarized in the following tables.

TABLE #1

Cereal Crop Yields - 10 Acre Plots. West of #855

YEAR	WHEAT	BARLEY	OATS	RAPESEED	RYE	WINTER WHEAT
1976	23.1	25.9	36.0	13.5	-	-
1977	17.7	29.4	53.9	-	26.9	-
1978	12.6	-	-	-	-	-
1979	23.3	-	46.4	-	-	15.0
1980	28.2	16.9	51.1	-	-	29.1

TABLE #2

Forage Crop Yields - 1 Acre Plots. West of #855

FORAGE	1977	1978	1979
Alfalfa	3,260 lbs.	3,900 lbs.	5,000 lbs.
Sainfoin	3,280 lbs.	3,760 lbs.	3,920 lbs.
Russian Wild Rye Grass	1,690 lbs.		
Altoi Wild Rye Grass	1,500 lbs.		
Intermediate Wheat Grass	1,810 lbs.		

TABLE #3

1977 Forage Yield Mixtures - 10 Acre Plots. East of #855

Mix #1	10 Acres	10,675 lbs.	.534 T/Ac
Mix #2	10 Acres	16,065 lbs.	.803 T/Ac
Mix #3	10 Acres	16,378 lbs.	.819 T/Ac
Sweet Clover (Plow Down)	10 Acres	27,143 lbs.	1.357 T/Ac

- In 1978 the area east of #855 was reworked and reseeded.
- In 1979 the 100-acre field east of #855 was leased out to a farmer who harvested an estimated 1.4 Ton/Acre.
- In 1980 the 100-acre field east of #855, the hay crop yield was an estimated 1.7 Tons/Acre.

Some very promising and impressive land restoration work is being done in the Battle River Planning Commission Region by Forestburg Colleries at their Diplomat mine site southwest of Foresburg.[11] This mine operation has been in progress since 1950. During the early years, reclamation initially included "striking off" some of the spoil piles, planting trees along with forage crop mixtures. Later, revised reclamation guidelines required levelling to new standards. Implementation of these new standards made it possible to utilize reclaimed land more efficiently. Forage crops were seeded for either cattle pastures or for harvesting as hay crops. Agricultural equipment could operate effectively and efficiently following levelling and rock picking.

Following passage of the Land Conservation and Reclamation Act in 1973 which requires conservation of top soil and potential root zone soil horizons, Forestburg Colleries integrated a top soil conservation program in the mining operation in 1975. Land mined in 1976 and 1977 and restored in 1977-1978 produced a field of spring wheat that yielded 36 bushels per acre in the fall of 1979. This crop of wheat was followed by a crop of barley seeded on May 23rd, 1980. This crop looked very good and compared very favorably with crops growing on nearby non-mined land when viewed in August, 1980. 1980 yield data indicate yields were comparative to yields in the adjacent undisturbed area. See Appendix #4.

PLATE 18.
Surface mining in background - 1980. Reclaimed area in foreground 1980. To be seeded in 1981.

PLATE 19.
1978-79 area stripped and mined. 1980 summerfallow. 1981 to be seeded.

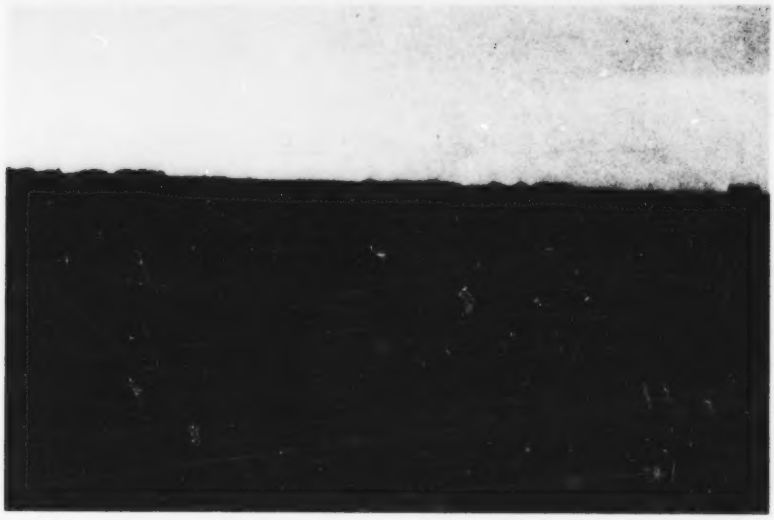

PLATE 20.
S.E. 32-40-15-W4M. 93 acres mined in 1976-77. 1978 area reclaimed and summerfallowed. 1979 wheat seeded - yield 36 bu/ac. 1979 area on left reclaimed and summerfallowed.

PLATE 21.
S.E. 32-40-15-W4M. Wheat seeded in 1979 - yield 36 bu/ac. Barley seeded in 1980 - yield 55 bu/ac.

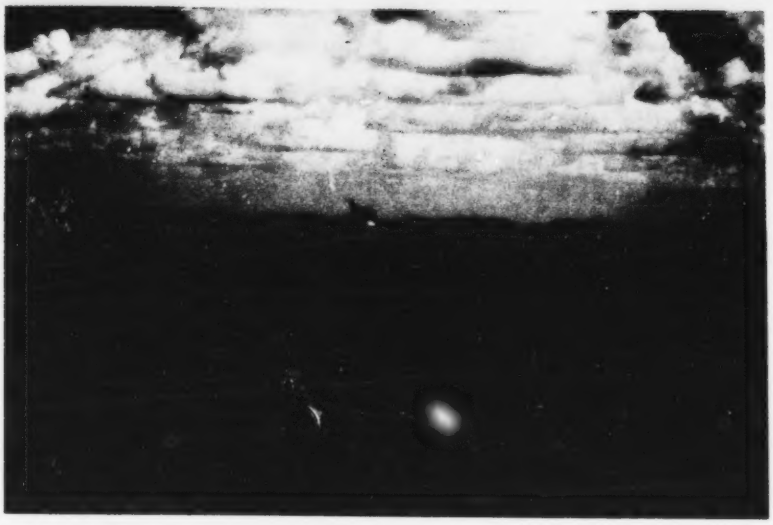

PLATE 22.
S.W. 32-40-15-W4M. Wheat seeded in 1979 - yield 27 bu/ac. Harmon oats seeded in 1980 - yield 65 bu/ac. 1978 - 84 acres reclaimed and summer-fallowed.

Along with the restoration and reclamation work done in the Forestburg area, small research plots have been established in different areas in the B.R.P.C. region. Shell Canada Resources Ltd. have initiated a field reclamation test plot on N.E. 9-46-26-W4m. The land leased for the test has a C.L.I. Class I classification.[12] The Alberta Soil Survey Report #14 classifies the plot area as Ponoka Loam - 60%, Angus Ridge Loam - 25%, and Peace Hills Sandy Loam - 15%.[13] The plot was prepared in 1978 and seeded to forage in 1979. A good growth of grass and legumes was observed in the spring of 1980.

Calgary Power Ltd. and Fording Coal Ltd. have initiated field reclamation test plots studies in the Round Hill area northeast of Camrose. In 1975 the first project was started on the S.W. 14-48-18-W4M located east and south of Round Hill. This research project required the excavation of a series of five trenches and then refilling them with mine spoil materials from an inactive coal mine located near by. The composition of the material utilized in the reconstitution of the trenches was developed in a manner to determine the most favorable growth medium for crop production in restored or reclaimed surface mine areas. The land in this area has a C.L.I. Class II classification.[5] The Alberta Soil Survey Report #14 classifies soil as Camrose Loam - 60%, Angus Ridge Loam - 20%, Beaver Hills Loam - 10%, and Slough Podsol - 10%[13]

The trench plots were fallowed after completion in 1975 and seeded with a cover crop of wheat in September to protect the test plot area from erosion. In the spring of 1976, the trenches were seeded with barley and an alfalfa-crested wheat grass mixture. Harvested yields indicated that the trenches top dressed with six inches of black top soil produced very acceptable yields of barley. In 1977 the hay yields from the 1976 seeded mixture varied from a high of 1.9 Tons per acre in the undistrubed land to a low of 0.9 Tons per acre on the trench plots with a mixture of 50% till and 50% shale. The 1979 hay yields ranged from a high of 3.4 Tons per acre on the original root zone mixed plot to a low of 2.2 Tons per acre on the undisturbed plot #3 in the test area.

In 1976, two test pits were excavated and reconstituted in different proportions to evaluate reclamation work. Pit #2, located on

PLATE 23.
Pit No. 2. Land Reclamation Research Project. Dodds-Round Hill. June 1977. S.E. 6-49-17-W4M.

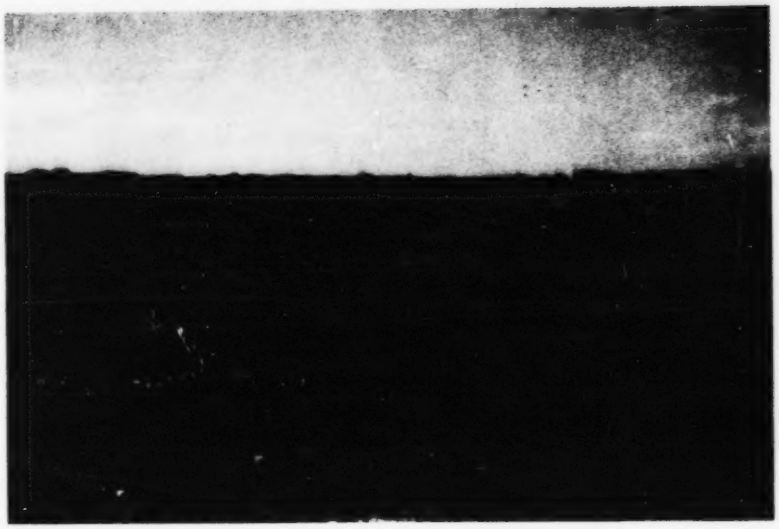

PLATE 24.
Pit No. 2. Land Reclamation Research Project. Subsidence and water problems. Autumn 1979. Dodd-Round Hill. S.E. 6-49-17-W4M.

PLATE 25.
Swathed crop on S.E. 6-49-17-W4M. Autumn 1979. Pit No. 2 on left-hand side of swaths.

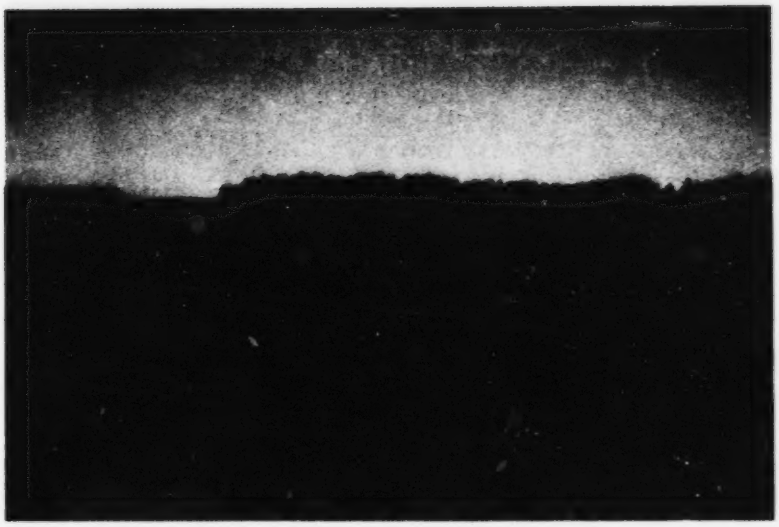

PLATE 26.
Pit No. 2 south to north. Autumn 1979. S.E. 6-49-17-W4M.

S.E. 6-49-17-W4M, was prepared as a research site to evaluate three items;

1. the upward movement of alkali salts (sodium) from mine spoils into thin layers of growth media;
2. the relative productivity of topsoil (Ah) and subsoil or "root zone mix" (B and C horizon mix) when such materials are used as thin surfacing on mine spoil;
3. the effect of gypsum upon the productivity of root zone material.[14]

This Pit #2 area has a similar C.L.I. Class II rating and overall soil composition classification as the trench site area. Pit #2 was seeded to barley and underseeded with an alfalfa grass mix in 1977. The barley crop (straw plus grain) was harvested after being frozen in the dough stage in October. The yield data showed the benefit of the application of the top soil (Ah) material. In 1978 this project site was enlarged and seeded to alfalfa and tall wheat grass in June. Seed germination and emergence was good. The Pit #2 project area was damaged by flooding in the late summer of 1978 and was reconstructed in 1979. No yield data was available for these two crop years.

The Pit #3 project area located on S.W. 9-49-17-W4M is in an area with a C.L.I. Class II rating similar to the other two project sites. The Alberta Soil Survey Report #21 indicates the upper soil profile consists of Angus Ridge Loam - 70% and Camrose Loam - 30%.[15] This plot site was reconstructed in 1976 after the coal had been removed. The top soil and root zone material were selectively sorted and stockpiled at the time of excavation for the coal removal. Once the coal was removed the spoil was replaced in the bottom of the pit and was surfaced with wedges of till and "root zone" mix. The wedges taper from eight feet thick on the east side to zero thickness on the west side. A part of each wedge was covered with six inches of top soil. This project at Pit #3 is intended to provide a demonstration of recommended methods of strip mine reclamation in the Camrose-Ryley area. It should be considered as an actual mine reclamation project since the coal was removed. The 1977 barley crop seeded in late June did not ripen. A killing frost hit the area on October 6th when the barley was in the dough stage. Yield data was recorded as a total weight (straw plus grain). The 1978 field operations included an application of Round-up on June 6th followed by

seeding the plot area on June 15th. A crested wheat grass-alfalfa mixture was used except on a 60 foot strip on the south end where the crested wheat grass was replaced by tall wheat grass in the mixture seeded. Two cuttings of the hay mixture were taken in 1979. Cutting #1 was taken on July 17th and 18th. The second cutting was taken on October 2nd 1979. The average yield varied from 3.5 Tons per acre on the till wedge with top soil added to 4.4 Tons per acre on the B + C mix wedge with top soil added.(16)

Other studies are being conducted on these differenct project areas each year along with the productivity studies. These studies include such items as nutritional quality of forage produced; soil analysis of the different "mixes" in the reconstituted soil profiles; correlation between hay yields and soil quality; chemical changes and physical changes in the soils in the project area along with related items. These land reclamation studies are relatively new. They have indicated a number of problem areas. The information being compiled now will provide a basis for the development of further studies. There are still problems to solve and questions to answer.

Summary

Since 1977, the primary objective in land reclamation in Alberta has been to assure that the mined or disturbed land will be returned to a state which will support plant and animal life or be otherwise productive or useful to man at least to the degree it was before it was disturbed.(17)

Land reclamation or restoration is relatively new in Alberta. The coal industry is obliged to look beyond the borders for research information. It is essential that detailed studies be done in areas proposed for disturbance before approval for surface mining is given. Problems vary between areas and even within project areas. There is a real need and opportunity for members of the industry, research and govenment departments, along with practical farmers, to share ideas, knowledge and expertise when developing programs for the restoration of disturbed agricultural land and to meet the objective established in 1977.

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APPENDIX

1. Coal-lease Holders
2. Coal Distribution in Counties
3. Flagstaff Reclamation Summary
4. Forestburg Colleries Crop Yields Data 1979-1980
5. 1975-1980 Estimated Acreage Disturbed by Well Drilling
6. 1975-1980 Table - No. of Oil & Gas Wells Drilled
7. Alberta "Transportation Composite" Roads 1980
8. Glossary of Terms

COAL LEASE HOLDERS

BATTLE RIVER PLANNING COMMISSION AREA

1. Map # SE 83G — Buck Creek - Pigeon Lake — 5 Sept./80

R1 W5M - R7 W5M

Township 46 (part) - 47 and part 48

81 Texaco Canada Inc.

156 Eagle Energy Ltd.

165 Petro-Canada Exploration Inc.

150 Eagle Explorations Ltd.

2. Map # SW 83H — Patience - Bittern Lake — 7 Oct./80

Wizard Lake

Range 22 W4M - Range 28 W4M

Township 46 (part) 47-48-49

1 Manalta Coal Ltd.

9 Forestburg Colleries Ltd.

30 Shell Canada Resources Ltd.

26 Pacific Petroleum Ltd.

100 Utah Mines Ltd.

158 Eagle Energy Ltd. & Duprey Engineering Ltd.

159 Gulf Canada Resources Inc.

3. Map # SE 83H — Tofield Dodds-Dinant-Dusty Lake — 8 Apr./80

Range 15 W4M - Range 21 W4M

Township #47 - #51 and part #52

7 Can Pac Minerals Ltd.

9 Forestburg Colleries Ltd.

30 Shell Canada Resources Ltd.

83 Calgary Power Ltd.

89 Norcen Energy Resources Ltd. &
Canadian Occidental Petroleum Ltd.

122 Can Pac Minerals Ltd. and Calgary Power Ltd.

123 Irving Industries (Foothills Steel Foundry Division) Ltd.

124 Jet Construction Ltd.

126 Irving Holdings Ltd.

4. Map # NE 83B Buck Lake - Alder Flats 24 Apr./80

156 Eagle Energy Ltd.

150 Eagle Explorations Ltd.

165 Petro-Canada Exploration Inc.

5. Map # NW 83A Ma-Me-O Beach, Bear Hills 13 Aug./80

Bashaw West

9 Forestburg Colleries

30 Shell Canada Resources Ltd.

83 Calgary Power Ltd.

85 City of Edmonton

152 Esso Resources Canada Ltd.

158 Eagles Energy Ltd. and Duprey Engineering Ltd.

159 Gulf Canada Resources Inc.

160 Alberta Energy Company

123 Irving Industries (Foothills Steel Foundry Division) Ltd.

150 Eagle Explorations Ltd.

6. Map # NE 83A Bashaw, Heisler, Ohaton 24 March/80

Range 15 W4M - Range 21 W4M

Township 41 - Township 46

30 Shell Canada Resources Ltd.

89 Norcen Energy Resources and Canadian Occidental Petroleum Ltd.

1 Manalta Coal Ltd.

9 Forestburg Colleries Ltd.

123 Irving Industries (Foothills Steel Foundry Division) Ltd.

7. Map # NW 73D Flagstaff East 7 Dec./77

26 Pacific Petroleum Ltd.

8. Map # SE 83A Flagstaff South-west 16 Oct./80

Diplomat Mine area

Vesta Mine area - south of Battle River

9 Forestburg Colleries Ltd.

89 Norcen Energy Resources and Canadian Occidental Petroleum Ltd.

RECOVERABLE COAL RESERVES[1]

	Deposit location[2]	No. of Seams	Aggregate Average Thickness of Coal		Surface	Under-Ground	Depth to Coal	
			Metres	Feet	10^6	tonnes	Metres	Feet
County of Flagstaff:								
Battle River Heisler	(3)	1	1.5	5 +	73	0	8- 52	26-170
Forestburg	(5)	1	2.2	7.2+	26	0	8- 20	26- 66
Donalda	(4)	3	3.1		0	26	47-133	155-436
County of Camrose:								
Driedmeat Lake	(1)	5	3.5	11.5	100	170	13-125	43-410
Meeting Creek	(2)	3	2.2	7.2	45	84	10-137	33-450
Tofield Dodds-Tofield South	(1)	2	1.7	5.6	33	0	9- 46	30-151
Dusty Lake	(2)	5	2.3	7.5	390	0	8- 46	26-151
Dinant	(3)	4	2.7	8.86	1	530	10-185	33-607
Ohaton	(4)	3	2.5	8.2	140	11	14- 61	46-200
County of Wetaskiwin:								
Wizzard Lake	(3)	3	2.8	9.2	100	38	19-126	62-413
Patience	(4)	6	3.8	12.5	210	0	15- 77	49-252
Falun	(5)	6	4.2	13.8	0	200	20-183	66-600
County of Ponoka:								
Bear Hills	(6)	2	3.1	10.2	0	62	28- 85	92-280

One Million Tons = 10^6 One Billion = 10^9

One Short Ton (2,000 lbs.) = 0.907 tonne

One long tonne (2,204 lbs.) = 1.102 Tons

	Surface Recoverable	Underground
	10^6 Tonnes	
Flagstaff	99	26
Camrose	709	795
Wetaskiwin	310	238
Ponoka	0	62
	1,118 10^6 tonnes +	1,121 10^6 tonnes
	1,118,000,000 tones	1,121,000.000 tonnes

= 2,239 Million tonnes or 2,467,378,000 Tons

(1) Table 6-3 E.R.C.B. Report #79-31
(2) Figure I E.R.C.B. Report #79-31

COUNTY OF FLAGSTAFF #29 - RESTORATION PROJECT

S.W. 1-41-16-W4M

1965 Area strip mined for coal by Forestburg Colleries Ltd. at the Diplomat Mine in the 1965 time frame.

1975 County of Flagstaff #29 working in cooperation with Forestburg Colleries and with support from Alberta Environment and Alberta Agriculture initiated a reclamation project on S.W. 1-41-16-W4M.

1975-76 Area was levelled during the winter of 1975-76. 146 acres levelled. Initial cost of levelling - $1,165.00/acre approximately.

1976 West side of #855. Area seeded in spring of 1976. Seeding program included (A) sowing a series of four 10-acre strips containing barley, rape, wheat and oats on the west side of Highway #855. This highway runs diagonally across the quarter from the north-west in a south-easterly direction, (B) sowing a series of six 1-acre strips containing a variety of legumes and grasses.

1976 East side of #855.

10-acre plots of grass legume mixtures with various levels of phosphorus and nitrogen applied.

1976 S.E. Corner East of #855

10 acres - poor drainage

- Bentonite problem

Straw incorporated -

Straw + Haulage + Incorporate = $60/acre.

1977 West side of #855. Approximately 45 acres seeded.

Cereals seeded. Rape was omitted from the rotation.

Summer fallow and fall rye were included in the rotation.

The grass legume plots were maintained.

1977 East side of #855. Approximately 100 acres.
Forage crop harvested.

1977 East side of #855. Late summer, approximately 100 acres.
(1) Area relevelled to correct subsidence problems.[a]
(2) Subsoiled with a ripper to a depth of 15 inches.[b]

1978 West of #855.
Cereal rotation maintained.
One-acre plots maintained on forage.

1978 East of #855.
Area reworked. Levelled, rocks picked and seed bed area restored.

1978 June forage seed mixtures seeded.
Good catch noticed in fall.

1979 West of #855.
Cereal plots maintained.
Forage plots maintained and harvested.

1979 West of #855. Crop Yields
Winter wheat looked poor - 15.5 bu./ac.
Oats - 46.4 bu./ac.
Wheat - 23.3 bu./ac.

1979 East of #855.
Hay harvested - large round bales.
i.e. Brome and alfalfa did well on all 25-acre plots.
Hay yield 282 bales - ½ ton each (estimate)
100 acres± harvested - 140 tons = 1.4 tons/ac.

1980 East of #855
Hay harvested - large round bales.
Hay yield - 296 bales - 1,150 lbs./bale
100 acres harvested - 170 tons = 1.70 tons/acre.

(a) Area relevelled - $11,220 - Alberta Environment.
(b) Ripping costs in 1977 - $1,470. Approximately 100 acres worked.

SUMMARY

FORESTBURG COLLERIES - DIPLOMAT MINE RECLAMATION PROJECT
CROP YIELD DATA - 1979-80

Location	Year	Crop Seeded	Acres	Yield
Pt. SE 32-40-15-W4M	1977-78	Reclaimed	93	
	1979	Spring Wheat	93	36 bu./ac.
	1980	Bonanza Barley	93	55 bu./ac.
Pt. SE 32-40-15-W4M	1979	Reclaimed	46	
	1980	Neepawa Wheat	46	35 bu./ac.
Pt. SW 32-40-15-W4M	1975-76	Reclaimed	68	West portion
		Deficient in top soil 1" - 3".		
	1979	Spring Wheat	68	27 bu./ac.
	1980	Harmon Oats	68	65 bu./ac.
Pt. SW 32-40-15-W4M	1978-79	Reclaimed	16	East portion
		8" - 10" top soil replaced.		
	1980	Harmon Oats	16	65 bu./ac.
Pt. NW 32-40-15-W4M	1977-78	Reclaimed	34	
	1979	Park Wheat	34	28 bu./ac.
	1980	Klages Barley	34	36 bu./ac.
Pt. NW 27-40-15-W4M	1979	Reclaimed		
	1980	Neepawa Wheat	25	34 bu./ac.
				Some duck damage
NE 31-40-15-W4M	1980	Grass & Legume Mix	50	
Balance of Mined Area	1980	Hay		1.5 ton/ac.

RAINFALL - A total of 45 cm of rain received on all seeded areas during growing season May - September 1980.

TABLE

ESTIMATED ACREAGE DISTURBED BY WELL DRILLING

ALBERTA, 1975 - 1980

YEAR	TOTAL WELLS DRILLED	AVERAGE AREA PER WELL SITE* (acres)	TOTAL ACREAGE DISTURBED
1975	3646	4.28	15,605
1976	5042	4.28	21,580
1977	5165	4.28	22,106
1978	5624	4.28	24,071
1979	5805	4.28	24,845
1980	5769	4.28	24,691
	31051		132,898

* (400' x 400') + (40' x 660') ÷ 43560

SOURCE: 1975 - 76 data: Canada Yearbook, 1978/79

: 1977 - 80 data: Personal communication with Energy Resources Conservation Board, December 16, 1980.

TABLE

NUMBER OF OIL AND GAS WELLS DRILLED, ALBERTA, 1975 - 1980

YEAR	OIL WELLS	GAS WELLS	DRY WELLS	STANDING	OTHER	TOTAL	ANNUAL INCREASE %
1975	670	1922	1064			3646	n/a
1976	550	3193	1229			5042	38.3
1977	639	2989	1202	121	214	5165	2.4
1978	817	3073	1290	151	293	5624	8.9
1979	809	2102	172	1395	227	5805	3.2
1980*						5769	-1.2

SOURCE: 1975 - 1976 data: Canada Yearbook, 1978/1979, P. 589.

1977 - 1980 data: Albert Johnson, Energy Resources Conservation Boad, December 16, 1980.

*1980 data refers to all wells drilled from January 1, 1980 - October 31, 1980 inclusive.

ALBERTA

"TRANSPORTATION COMPOSITE"

I. Rural Highways and Roads (1980)

Classification	Mileage	Acreage
Primary	8,074	146,946
900 Series Roads	383	6,970
	(106 miles not open)	(1,929)
Secondary Roads	9,876	119,500
Approach Roads	199	2,407
Park Roads	172	2,081
Local Roads	73,940	591,526
	(86,596 miles not open)	(692,768)
Total	*92,644	*869,430

Source: Alberta Transportation (E.D. & R.T.S.)
* Figures exclude local road not open.

II. Urban Roads

Cities/Other	Mileage	Acreage
Calgary	1,686	16,186
Edmonton	1,603	15,389
Ft. McMurray	109	1,046
Grande Prairie	80	768
Lethbridge	231	2,217
Medicine Hat	230	2,208
Red Deer	170	1,632
St. Albert	85	816
Other	6,792	65,203
Total	10,986	105,465

Source: Alberta Transportation (P.P.D.)

III. Interchanges (1980)

Number	Acreage
84 currently in operation	*1,865

Source: Alberta Transportation (E.D.)
Excludes Highway & Service Road right-of-way

IV. Airports (1979)

Location	Acreage
Edson	270.78
Pincher Creek	386.089
Rocky Mountain House	175.550
Jasper/Hinton	320.86
Whitecourt	707.45
Grande Cache	222.82
High Level (Footner Lake)	271.31
Fort Chipewyan	341.20
Slave Lake	156.34
Swan Hills	361.11
Fort VErmillion	201.80
Lac La Biche	276.31
Lloydminster	475.18
Total	4,166.8

Source: Alberta Transportation (Airport Eng.)

0.1% or 1/1000 of Alberta's total land area is presently occupied by transportation facilities.

Glossary of Terms

Acid soil	-	A soil material having a pH of less than 7.0.
Alkali soil	-	A soil having pH greater than 7.0 on the pH. scale.
Agronomy	-	The branch of agriculture that deals with the theory and practice of field-crop production and the scientific management of soil.
Amendment soil	-	(i) An alteration of the properties of a soil, and thereby of the soil, by the addition of substances such as lime, gypsum and sawdust to make the soil more suitable for the growth of plants. (ii) Any substance used.
Arable soil	-	Soil suitable for plowing and cultivation.
Derelict land	-	Land so damaged by industrial or other development that it is incapable of beneficial use without treatment.
Ecology	-	The study of the relationship between organisms and their environment.
E.C. - Electrical Conductivity	-	A method of measuring the amount of total salts in the soil.
Eolian deposit	-	Sand, or silt, or both deposited by the wind.
Gob piles	-	Piles of solid contaminated waste from coal mining operations.
Loess	-	Material transported and deposited by wind and consisting of predominantly silt-sized particles.

Lacustrine deposit - Material deposited in lake water and later exposed either by lowering of the water level or by uplifting of the land. These sediments range in texture from sand to clays.

Lime, agricultural - A soil amendment consisting principally of calcium carbonate, and including magnesium carbonate and perhaps other materials. It is used to supply calcium and magnesium as essential elements for growth of plants and to neutralize soil acidity.

Marl - A soft, unconsolidated earthy deposit consisting of calcium carbonate or magnesium carbonate or both, and often shells, usually mixed with varying amounts of clay or other impurities.

Mineral soil - A soil consisting predominantly of and having its properties determined by mineral matter.

Montmorillonite group - Clay minerals having a 2:1 expanding crystal lattice; smectite and vermiculite along with montmorillonite make up this group of hydrous platy clay minerals.

Neutral soil - A soil in which the surface layer to plow depth is neither acid or alkaline in reaction.

Parent material - The unconsolidated and more or less chemically weathered mineral or organic matter from which the upper soil horizons are formed.

Piping - A word used to indicate the process of surface water working down through cracks in the soil surface and carrying surface soil with it.

Profile	-	A vertical section of the soil through all its horizons and extending into the parent material.
Reclamation	-	The process of bringing waste or swamp land to a condition of usefulness or productiveness.
Restoration	-	The process of bringing land back to its original condition after surface mining.
Saline soil	-	A non alkali soil that contains enough saluble salts to interfere with the growth of most crops.
Slumping	-	The sudden settling of a disturbed soil area.
Sodic soil	-	A soil containing sufficient sodium to interfere with the growth of most crops.
S.A.R. - Sodium Adsorption Ration	-	A method of measuring the amount of sodium present in the soil.
Soil Horizon	-	A layer of soil or soil material approximately parallel to the land surface.
Soil pH	-	A measure of the degree of acidity or alkalinity of a soil expressed in terms of the pH scale. pH 7.0 neutral.
Soil Zone	-	Area in which the dominant of zonal soils reflect the zonal influence of climate and vegetation and form a natural land pattern with other soils that exhibit the zonal influence only weakly or not at all.
Solod	-	A group of soils in the solonetzic order occuring most commonly in the grassland and parkland regions.

Solonetzic	-	An order of soils developed mainly under grass or grass forest vegetative cover in semiarid to sub-humid climates. Soils have a stained brown B horizon and a saline C horizon.
Solum	-	The upper horizons of a soil in which the parent material has been modified and in which most plant roots are contained. It usually consists of the A & B horizons.
Striking Off	-	Levelling the peaks of spoil piles to ease traffic movement.
Subsidence	-	The gradual settling of a disturbed soil area.
Till	-	Unstratified glacial drift deposited directly on the ice consisting of clay, sand, gravel, and boulders intermingled in any proportion.